DESIGN AND FABRICATION OF TREE PLANTATION MACHINE

Project Reference No.: *47S_BE_3055*

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Introduction

Background Review

A tree plantation, forest plantation, plantation forest, timber plantation or tree farm is a forest planted for high volume production of wood, usually by planting one type of tree as a monoculture forest. The term tree farm also is used to refer to tree nurseries and Christmas tree farms. Plantation forestry can produce a high volume of wood in a short period of time. Plantations are grown by state forestry authorities (for example, the Forestry Commission in Britain) and/or the paper and wood industries and other private landowners (such as Weyerhaeuser, Rayonier and Sierra Pacific Industries in the United States or Asia Pulp & Paper in Indonesia). Christmas trees are often grown on plantations, and in southern and southeastern Asia, teak plantations have recently replaced the natural forest. Industrial plantations are actively managed for the commercial production of forest products.

Industrial plantations are usually large-scale. Individual blocks are usually even aged and often consist of just one or two species. These species can be exotic or indigenous. The plants used for the plantation are often genetically altered for desired traits such as growth and resistance to pests and diseases in general and specific traits, for example in the case of timber species, volumed wood production and stem straightness. Forest genetic resources are the basis for genetic alteration. Selected individuals grown in seed orchards are a good source for seeds to develop adequate planting material.

Wood production on a tree plantation is generally higher than that of natural forests. While forests managed for wood production commonly yield between 1 and 3 cubic meters per hectare per year, plantations of fast-growing species commonly yield between 20 and 30 cubic meters or more per hectare annually; a Grand Fir plantation in Scotland has a growth rate of 34 cubic meters per hectare per year, and Monterey Pine plantations in southern Australia can yield up to 40 cubic meters per hectare per year. In 2000, while plantations accounted for 5% of global forest, it is estimated that they supplied about 35% of the world's round wood.

As labor for manual tree planting becomes scarcer, regeneration costs are steadily increasing in Indian forestry. Today's intermittently advancing tree planting machines provide excellent silvicultural results but are expensive to operate because of poor productivity. In contrast, continuously advancing planting machines, thanks to high productivity, are increasingly being regarded as a solution to these runaway regeneration costs.

A tree spade is a specialized machine that mechanizes the transplanting of large plants whose hand-powered transplanting (using traditional spades, wagons, and other equipment) would be prohibitively laborious. These include large bushes and small or medium trees. By bringing mechanized power to what was formerly only a manual process, tree spades do for transplanting what tractors and combine harvesters do for agriculture, and what excavators and other heavy equipment do for construction. Today, tree spades are widely used in the tree nursery industry to increase production rates, and in the landscaping industry for tree removal and transplanting. But the cost of a tree spade is higher and normal human beings cannot affordable. Figure 1.1 shows planted saplings and figure 1.2 shows mechanized farming.

Figure 1.1: Planted Sapling

Figure 1.2: Mechanized

Farming

The Tree Plantation Machine project is a visionary initiative aimed at revolutionizing afforestation practices through the integration of advanced technology. In the face of escalating global challenges such as deforestation, climate change, and biodiversity loss, this project emerges as a novel approach to tree planting that combines innovation, efficiency, and environmental responsibility. The machine is designed to operate autonomously or with operator assistance, with a primary focus on significantly enhancing the speed and precision of tree planting operations. This innovation is vital, considering the scale and urgency of reforestation efforts needed to counteract the adverse effects of deforestation.

It aims to improve the efficiency of tree planting by leveraging technological advancements. The machine's adaptability to diverse & harsh environmental conditions is a key feature, ensuring its effectiveness in various ecosystems. Moreover, the project places a strong emphasis on environmental sustainability, incorporating eco-friendly materials and energy sources to minimize its ecological footprint. By automating labor-intensive tasks associated with traditional tree planting, the machine not only reduces the demand for human labor but also enhances precision and success rates.

Moreover, the Tree Plantation Machine project is not just a technological endeavor but also a commitment to environmental stewardship. By harnessing the power of automation and innovation, we aim to minimize the ecological impact of tree planting activities while maximizing their effectiveness. The machine's adaptability to diverse and harsh environmental conditions is a key feature, ensuring its reliability and success in various ecosystems, from arid landscapes to dense forests.

In addition to its environmental benefits, the project has significant socio-economic implications. Traditional manual tree planting methods often require substantial labor, which can be both costly and time-consuming. With the implementation of the Tree Plantation Machine, we envision a future where tree planting operations are not only more efficient but also more accessible to a wider range of stakeholders. This includes small-scale farmers, community groups, and government agencies, all of whom can benefit from the machine's capabilities in scaling up tree planting initiatives.

The integration of cutting-edge technology into forestry practices is a paradigm shift that reflects our commitment to progress and sustainability. Through collaborations with industry experts, environmental organizations, and local communities, we have developed a machine that not only meets the demands of modern forestry but also aligns with global initiatives for climate action and conservation. As we embark on this journey of innovation and impact, it is essential to acknowledge the support and contributions of our partners and stakeholders. Their expertise, feedback, and collaborative spirit have been instrumental in shaping the Tree Plantation Machine project into a groundbreaking initiative with the potential to reshape the future of afforestation.

The Tree Plantation Machine project represents a culmination of interdisciplinary efforts, combining expertise from fields such as engineering, environmental science, forestry, and technology development. This collaborative approach has been essential in ensuring that the machine not only meets technical requirements but also aligns with ecological principles and societal needs.

One of the core objectives of this project is to address the growing challenges associated with manual tree planting, especially in the context of labor scarcity and increasing regeneration costs. As labor for manual tree planting becomes scarcer, regeneration costs are steadily increasing in Indian forestry. Today's intermittently advancing tree planting machines provide excellent silvicultural results but are expensive to operate because of poor productivity. In contrast, continuously advancing planting machines, thanks to high productivity, are increasingly being regarded as a solution to these runaway regeneration costs.

The adoption of advanced planting technology, such as the Tree Plantation Machine, is essential for scaling up reforestation efforts and meeting ambitious targets for afforestation and climate mitigation. With the ability to plant trees at a faster rate and with greater precision, the machine contributes to enhancing forest cover, carbon sequestration, and ecosystem restoration, all of which are critical components of sustainable development.

Problem Definition:

- The current manual methods of tree plantation are labor-intensive, time-consuming, and often lack precision, leading to inefficiencies and suboptimal outcomes.
- This project aims to address these challenges by designing and fabricating a tree machine should be capable of accurately planting trees at designated locations, while also considering factors such as soil conditions and environmental sustainability.
- By doing so, the project seeks to improve the efficiency, accuracy, and overall effectiveness of tree plantation efforts, contributing to environmental conservation and sustainable land management practices.

Literature Review

Literature Survey

A literature review is a survey of scholarly sources on a specific topic. It provides an overview of current knowledge, allowing us to identify relevant theories, methods, and gaps in the existing research.

The following papers have been surveyed by us in context to our Project,

Linnea J. Hansson et al. (2024): To ensure that new forests are developed as soon as possible, sustainable forestry requires effective regeneration techniques. In Sweden, physical labor is used for 99% of the planting process, although labor is hard to come by. An autonomous device that plants and scarifies with great accuracy and minimal environmental impact and a comfortable workplace would satisfy the demands of the woods sector. Researchers, producers, and consumers (forest companies) have been collaborating over the past two years to develop and test a novel idea for autonomous forest regeneration called Auto plant. Subsystems included in the proposal are regeneration and route planning; autonomous driving (path planning); new technology for minimally impactful forest regeneration; automatic plant management; crane motion planning; planting spot recognition; and follow-up. At a clearcut, the subsystems underwent individual testing before being merged during a field test. The idea has a lot of promise, particularly when it comes to the environment, as evidenced by the drastically lower soil disturbances—from roughly 50% of the area disturbed by disc trenching to less than 3%. The Auto plant project sheds light on the opportunities and challenges associated with further development. Some of these include the relationship between machine cost and operating speed, the robustness of sensors in response to weather and vibrations, and the accuracy of obstacle detection during autonomous driving and planting [1].

Jussi Manner, Back Tomas Ersson (2021): As labor for manual tree planting becomes scarcer, regeneration costs are steadily increasing in Nordic forestry. Today's intermittently advancing tree planting machines provide excellent silvicultural results but are expensive to operate because of poor productivity. In contrast, continuously advancing planting machines, thanks to high productivities, are increasingly being regarded as a solution to these runaway regeneration costs. The Silva Nova was a historical, continuously advancing tree planting machine with high productivity. However, Silva Nova's weaknesses included high labor costs (it required two operators) and the random nature of how it chose planting spots. In contrast, Super Silva, a purely conceptual modernization of Silva Nova, involves both automation and microsite identification to make the machine more efficient. We used discrete-event simulation to analyze the stocking rate and spatial distribution of tree planting with Super Silva. The simulation results showed that introducing sensors for identifying suitable microsites will allow continuously advancing planting machines (like Super Silva) to plant seedlings in a numerically spatially adequate manner on moraine soils. Hence, these sensors will increase the competitiveness and versatility of tree planting machines. Unfortunately, such reliable and robust sensor technology (unaffected by a wide variety of operating conditions) is not yet commercially available [2].

Dagnija Lazdina et al. (2019): Soil preparation method – mounding (with varying depth of the pit and the mound height) – may be the solution for establishing new forests when the soil water regime is unfavourable since the pit serves as a reservoir for water during rainy periods and can retain water for the dry season. Thus, seedlings planted on mounds may obtain water through the soil capillary system when needed. During the last decades extreme weather conditions have occurred more often. And as there is a labour shortage for simple forest management tasks and increased hourly labour cost mechanized planting on mounds could be a promising solution to advance tree planting practices in Latvia. The aim of this study was to compare the productivity, quality and cost of mechanized planting and manual planting in Latvian conditions, where planting density of 2-2.5 thousand seedlings per ha is used. The M-planter was selected for the mechanized establishment of forest sites on\ mounded soils. During field trials, when 2000 trees per ha were planted, the productivity of the M-planter was 11.2 h ha on drained peat soils, 11.6 h per ha on drained mineral soils and 14.1 h per ha on wet mineral soils. Average mechanized planting time per 1 ha was 11.9 h, while making mounds and manual planting together took 11.2 h per ha. The cost of mechanized planting experiments in Latvian conditions, depending on the number of seedlings planted and planting conditions varied between 450 and 550 EUR per ha. Tree establishment success did not differ between the sites with mechanized or manually planted seedling but depended more on the local site conditions [3].

Olimpia PANDIA et al. 2014: The section is equipped with a mechanism for the movement transmission of several elements which are pot bearers, whose position to the soil in vertical plan remains constant to the slope of the terrain. It receives the rotation movement by Gall chain from a wheel which copies the soil, and it presents the possibility of the adjustment of the distance between the plants in the row. The section may be a component of a seedling planting machine in pots in 1– 2 rows, when the terrain is covered with foil mulch or from 1 to 6 rows on uncovered terrain. It may be a component of an agricultural aggregate for soil processing, for mounting foil mulch, for mounting hose for watering by processing. The transmission of the movement from the copy wheel presents the possibility of the adjustment of the revolution for the adjustment of distance between the rows, and the elements that support the pots bearer’s parts present the possibility of the length modification in the same purpose [4].

Mohammed Amer, et al. [2020]: The agriculture sector occupies more than 25% of the total gross domestic products in Palestine. This provides jobs for more than 15.2% of the population in the West Bank and Gaza Strip. The cultivated land is over 1.854 million dunum. However, people still use traditional ways of planting which would consume time and effort. Agriculture faces huge costs and transplant losses during planting. In this study, an automated planting machine has been introduced. This machine is a hand to the agriculture sector in Palestine. It is proposed to increase the speed and precision of planting. It is designed to do the basic cultivation steps by transmitting the transplant gently to the land. The study focused on the plants used in Palestine considering their dimensions and the distance between each two neighbor seedlings. The simulation and experimental results for the prototype showed an accurate functioning of the controlled system. Besides a precise and smooth processing during planting, the basic planting steps were done in a satisfied way from plowing passing through planting to covering it with soil. By designing this machine, the main concerns could be achieved as human needs, cost, and time saving.[5]

Istevin Appavoo, et al. [2017]: The labor shortage, the need to increase the forest density and the great increase in surface for planting trees has led to a reflection in R&D. This article discusses the abilities of a tree planting machine which works automatically. The need to design this type of machine was due to the massive exploitation of forests done by the wood industry and subsistence farming. The device which is hitched up to a tractor can plant in the presence of tree stump and vegetable wreckage. Several hydraulic actuators work in parallel to enable the plantation of one tree per second (a machine with two planting organs). The planting organ has been designed to plant trees without stopping the tractor.[6]

James A. Mattson, et al. [2019]: A promising approach to increasing the supply of wood fiber for pulp and energy is short-rotation intensively cultured (SRIC) forestry. To apply the principles of agriculture to the growing of wood fiber, designers of harvesting equipment must consider a unique set of operating criteria. This paper summarizes the design criteria relevant to the SRIC concept and describes the results of initial trials with a prototype short-rotation harvester.[7]

Chiung-Hsing Chen, et al. [2022]: Agriculture is a labor-intensive traditional industry. As times change, more and more people are unwilling to engage in agriculture, resulting in a large shortage of agricultural manpower. Therefore, all parts of the world have begun to promote agricultural automation to solve the problem of serious shortage of manpower. In traditional agriculture, when transplanting vegetable seedlings, farmers need to bend down to dig holes for each vegetable seedling to be planted. This method is not only laborious but also extremely inefficient. In this study, we use a self-developed robotic arm combined with a traditional planter and motor to make an automatic planting machine to achieve automatic planting of vegetable seedlings by the machine to reduce labor costs. This will further help agricultural automation. [8]

Jussi Manner, et al. [2021]: As labor for manual tree planting becomes scarcer, regeneration costs are steadily increasing in Nordic forestry. Today's intermittently advancing tree planting machines provide excellent silvicultural results but are expensive to operate because of poor productivity. In contrast, continuously advancing planting machines, thanks to high productivity, are increasingly being regarded as a solution to these runaway regeneration costs. The Silva Nova was a historical, continuously advancing tree planting machine with high productivity. However, Silva Nova's weaknesses included high labor costs (it required two operators) and the random nature of how it chose planting spots. In contrast, Super Silva, a purely conceptual modernization of Silva Nova, involves both automation and microsite identification to make the machine more efficient. We used discrete-event simulation to analyze the stocking rate and spatial distribution of tree planting with Super Silva. The simulation results showed that introducing sensors for identifying suitable microsites will allow continuously advancing planting machines (like Super Silva) to plant seedlings in a numerically and spatially adequate manner on moraine soils. Hence, these sensors will increase the competitiveness and versatility of tree planting machines. Unfortunately, such reliable and robust sensor technology (unaffected by a wide variety of operating conditions) is not yet commercially available. [9]

2.2 Summary of Literature review:

Tree Plantation drives combat many environmental issues like deforestation, erosion of soil, desertification in semi-arid areas, global warming and hence enhancing the beauty and balance of the environment. Trees absorb harmful gases and emit oxygen resulting in an increase in oxygen supply. On average, a single tree emits 260 pounds of oxygen annually. Similarly, a fully-grown tree is sufficient for 18 human beings in one acre of land in one year stressing the importance of tree plantation for mankind.

1. Machine planting is another common planting method in India. Equipment and transportation costs are such that machine planting is generally used for larger acreages where reduced labor cost and high planting productivity are desired.
2. More Yielding can be achieved.

Table No.2.1: Summary of Literature Review

SL. No	Author's Name	Paper Title	Target Achieved
01	**Linnea J. Hansson** PhD in Soil Science M.Sc in Forestry (2024)	"Auto plant—Autonomous Site Preparation and Tree Planting for a Sustainable Bioeconomy"	An autonomous device that plants and scarifies with great accuracy and minimal environmental impact and a comfortable workplace would satisfy the demands of the woods sector.
02	**Jussi Manner, Back Tomas Ersson** School of Forest Management Doctor of Philosophy, Forest Management	"Mechanized tree planting in Nordic forestry: simulating a machine concept for continuously advancing site preparation and planting"	Super Silva, a purely conceptual modernization of Silva Nova, involves both automation and microsite identification to make the machine more efficient. We used discrete-event simulation to analyze the stocking rate and spatial distribution of tree planting with Super Silva. The

	(2021)		simulation results showed that introducing sensors for identifying suitable microsites will allow continuously advancing planting machines (like SuperSilva) to plant seedlings in a numerically and spatially adequate manner on moraine soils.
03	**Dagnija Lazdina** Latvian State Forest Research Institute "Silava", Latvia (2019)	"Evaluation Of Forest Tree Planting Machine Effectiveness"	The M-planter was selected for the mechanized establishment of forest sites on\ mounded soils. During field trials, when 2000 trees per ha were planted, the productivity of the M-planter was 11.2 h ha on drained peat soils, 11.6 h per ha on drained mineral soils and 14.1 h per ha on wet mineral soils. Average mechanized planting time per 1 ha was 11.9 h, while making mounds and manual planting together took 11.2 h per ha. The cost of mechanized planting experiments in Latvian conditions, depending on the number of seedlings planted and planting

			conditions varied between 450 and 550 EUR per ha.
04	**Olimpia Pandia** Conferențiar, USAMV București (2014)	"Section For The Seedling Planting Machine In Nutritive Pots"	The pot planting section ensures uniformity in plant spacing and sowing depth. The planting machine, featuring two, four, or six sections, offers adjustable cup positions for various pot shapes and sizes. Mechanized planting reduces time and costs while allowing for additional operations during the crop's growth period.
05	**Mohammed Amer** Palestine Technical University-Kadoorie (2020)	"Design and Development of an Automatic Controlled Planting Machine for Agriculture in Palestine"	An automated planting machine is introduced in agricultural research, emphasizing its significance in human life. Like other innovations such as tractors and plows, this prototype aims to enhance efficiency in planting. Initial tests demonstrate satisfactory performance, indicating potential suitability for deployment in developed countries.
06	**Istevin Appavoo** SATT Grand	"A high yield automatic tree planting machine"	The GCplanter, funded by Alliance Forêts Bois, is undergoing real-world

	Centre (2016)		testing with adjustments made for stability and height consistency. Design challenges have been met to ensure efficiency in chaotic forestry environments. This innovative solution aims to tackle reforestation difficulties and labor shortages.
07	**James A. Mattson** Department of Chemistry, University of Michigan, Ann Arbor, Michigan (2019)	"A Prototype Harvester for Short-Rotation Plantations"	The harvester's auger cutting system was optimized, addressing chip clearance issues. Redesigned sliding guides improved the auto-retracting system's performance. Further research aims to refine directional felling and explore innovative concepts for combined operations.
08	**Chiung-Hsing Chen** Department of Electronic Communication Engineering National Kaohsiung University of	"Unmanned Self-propelled Vegetable Seedling Planting Vehicle Based on Embedded System",	The developed unmanned self-propelled vegetable seedling planting vehicle offers automatic operation, improving watering habits and saving resources. Further enhancements are needed for commercialization, including improvements in

	Science and Technology Kaohsiung, Taiwan, R.O.C. (2022)		stability, production processes, and operating speed. Once achieved, it can meet commercialization requirements.
09	**Jussi Manner** Researcher (PhD) Forest operations Uppsala Science Park (2021)	"Mechanized tree planting in Nordic forestry: simulating a machine concept for continuously advancing site preparation and planting",	The study focused on favorable conditions for mechanized tree planting but anticipates advancements for stonier sites with sensor technology. Simulation outcomes suggest potential for partly automated planting machines, but further research is needed for effective integration of sensor technology.

2.3 Research Gap:

- **Food crisis**: while planting productive trees in dry and eroded areas, the food production will be increased. This allows us to meet the demand for food, especially in poor countries.
- **Climate change**: it can't be news that trees have a positive effect on the CO2 concentration in the air.
- **Reduction of the groundwater levels**: the groundwater levels are dropping in many places in the world. People think that trees are also lowering the groundwater levels, but this is not true. The roots of trees hold the water in the ground.
- **Migration to cities from the countryside**: people are leaving from the countryside because there aren't jobs anymore. With the Grouses Ecological Water Saving Technology, we can create 1 direct and 1 indirect job per hectare.

- **Shortage of drink water**: in the future, a lot of people will have to face drink water shortages. We must be careful with drink water. The biggest part of fresh water is used to produce food. With the Grouses Ecological Water Saving Technology you can save 90% water compared to drip irrigation.
- **Cutting down the forests**: forests are cut down because it provides quick money. We can stop this with our technology. By planting productive trees that provide more money than cutting trees. In this way, we can save the last precious forests.
- **The population will grow to 10 million people in 2050**: more and more people will be on earth and every need food. By planting trees, we can increase the food production, and nobody must suffer from hunger in the future!

OBJECTIVES AND METHODOLOGY

3.1 Objectives of The Project:

In the literature review, it is found that there is a scope for automated tree plantation machines. This research gap found in the literature review can be solved with the following objectives:

- To design, develop, test, and adopt improved tree planting machine implements and machinery for different agro-climatic regions, and operations suitable for animate, mechanical, and electric power sources to increase plantation production and land and labor productivity.
- To conduct feasibility testing of prototypes of proven designs of farm implements and machinery
  on farmer’s fields, selected from different regions for adoption under local conditions to bridge the identified mechanization gaps.
- To conduct a frontline demonstration of new designs of farm implements and machinery selected from different regions on farmer’s fields to test their efficiency for adoption and popularization under local conditions to bridge the identified mechanization gaps.
- To develop the traditional planting methods, with the modernization techniques in the Foresting sector. Introducing automated planting machines

tailored to meet needs presents a solution to enhance precision, efficiency, and cost-effectiveness.

3.2 Methodology:

The methodology for this project starts with a clear articulation of project objectives, delineating specific goals, performance criteria, and desired results. This initial step lays down the roadmap for the entire design and development journey. Subsequently, an extensive literature review is undertaken to assimilate insights from existing research, technologies, and best practices pertinent to tree plantation machines, automation methodologies, and environmental sustainability in afforestation endeavors. This phase acts as a knowledge foundation, informing subsequent decisions and strategies.

Following the literature review, brainstorming sessions are conducted to foster creativity and generate innovative ideas and concepts. These sessions emphasize efficiency enhancements, automation capabilities, and environmental considerations in the design process. Concurrently, detailed engineering drawings are crafted using CAD tools, translating conceptual designs into tangible blueprints that encompass mechanical specifications, system architectures, and component layouts. Material selection is also a critical aspect at this stage, focusing on the choice of materials that offer optimal strength, durability, lightweight properties, and eco-friendly attributes to align with sustainability goals. The fabrication phase then ensues, employing welding, machining, and assembly techniques to construct a prototype of the tree plantation machine as per the design specifications. Rigorous testing and validation procedures follow to evaluate the prototype's performance, functionality, safety, and adherence to design standards, facilitating iterative improvements and optimizations to enhance overall efficacy and reliability.

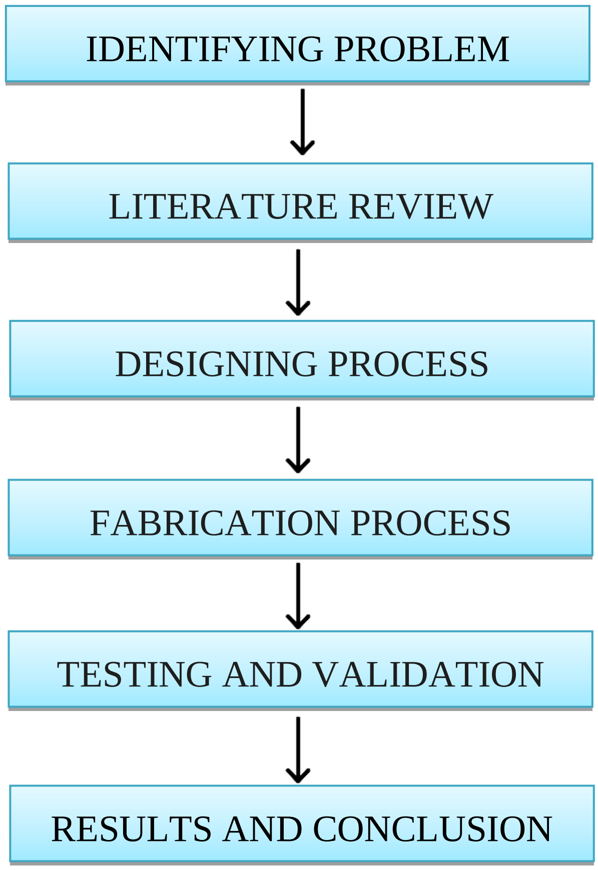


Figure 3.1: Methodology Flow Chart

Figure 3.1 shows the methodology followed to carry out project work.

DESIGNING PROCESS

4.1 CAD Design

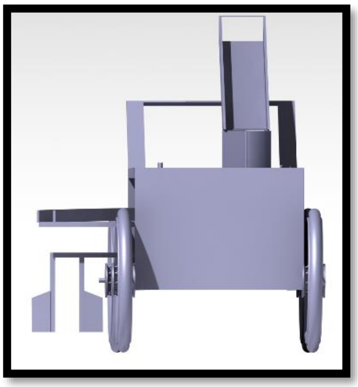
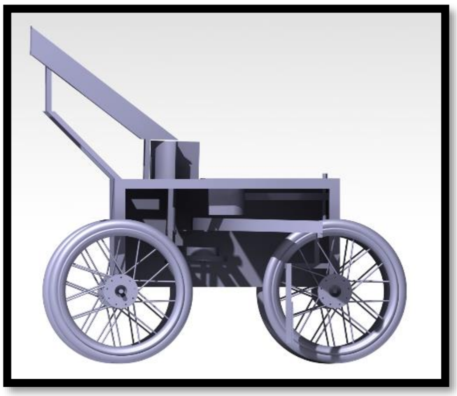
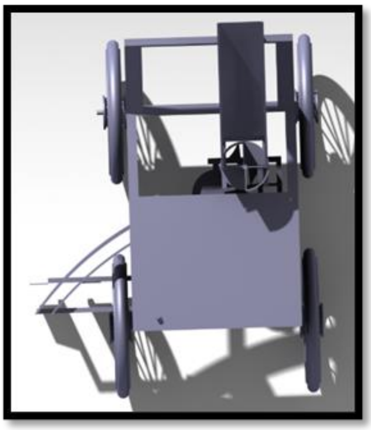
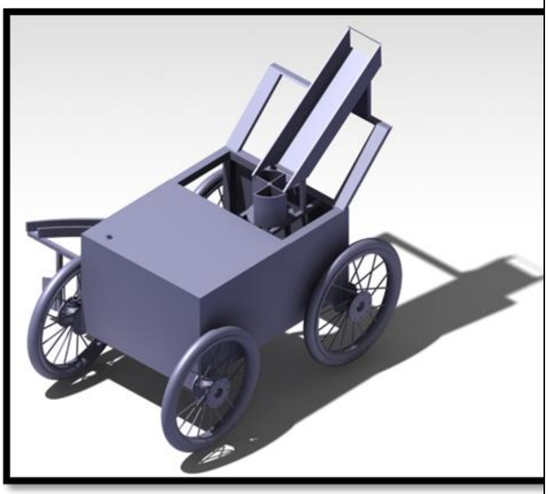
 Front View	 Side View
Top  View	Isometric View 

Figure 4.1: CAD Model of the Machine

Figure 4.1 shows the created model using Catia V5 and dimensions were calculated. The model was created with proper dimensions.

4.2 Line Diagram

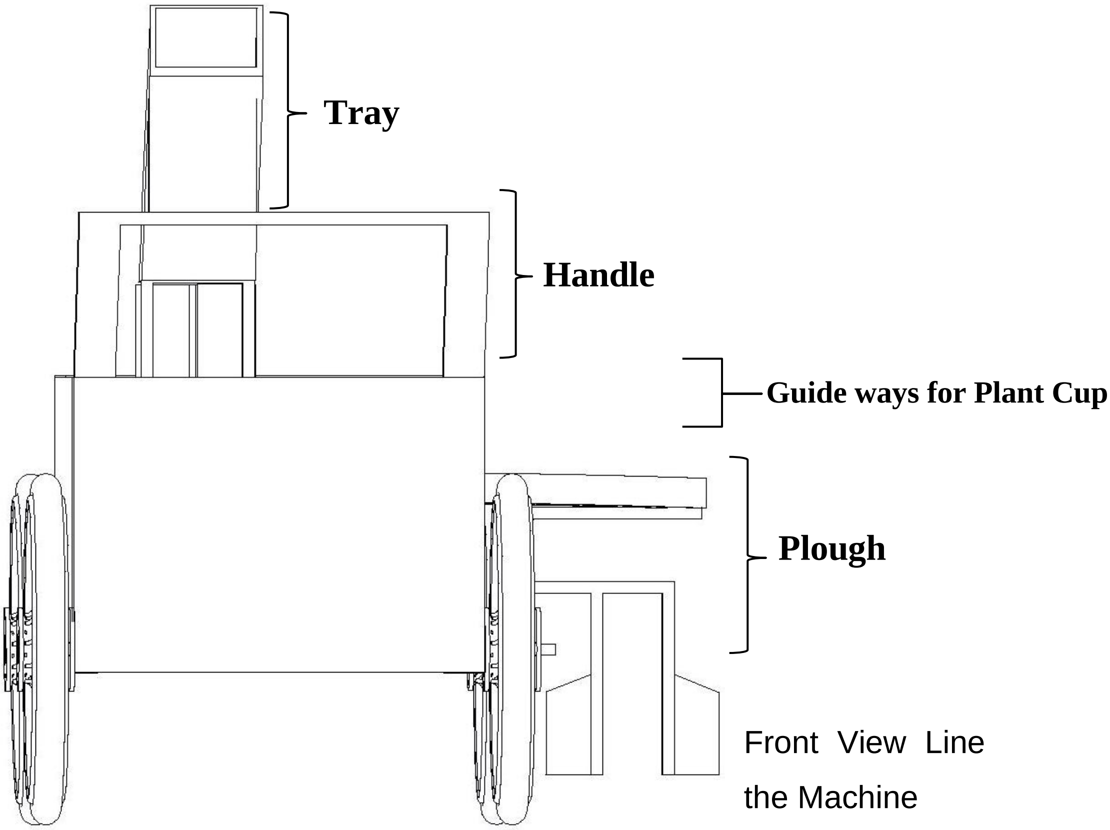


Figure 4.2: Front View Line diagram of the Machine

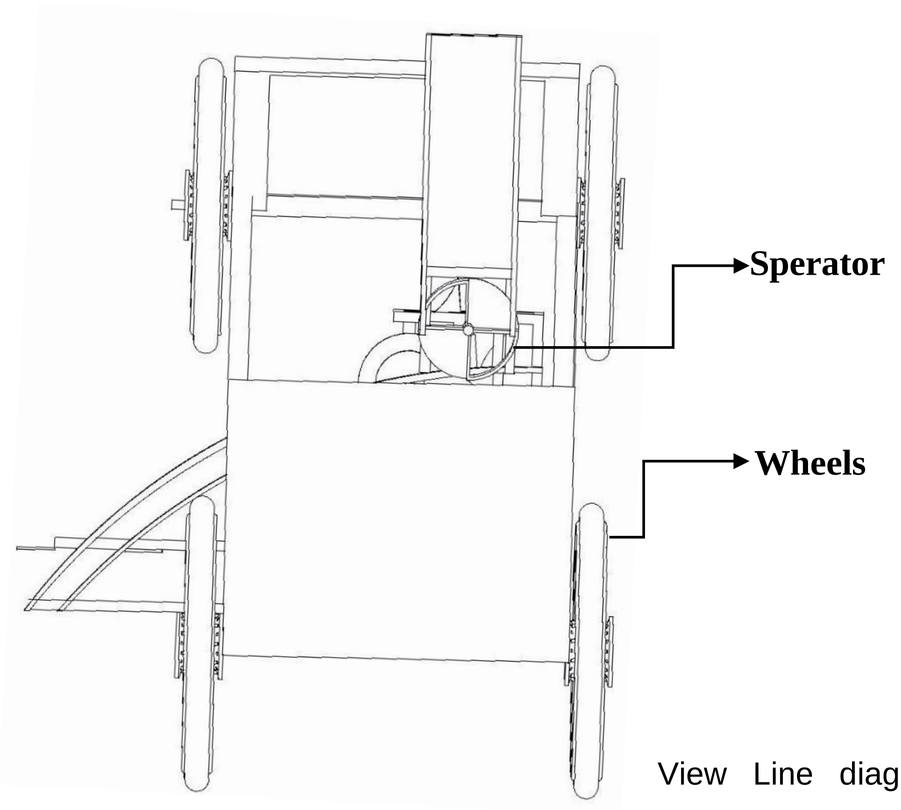


Figure 4.3: Top View Line diagram of the Machine

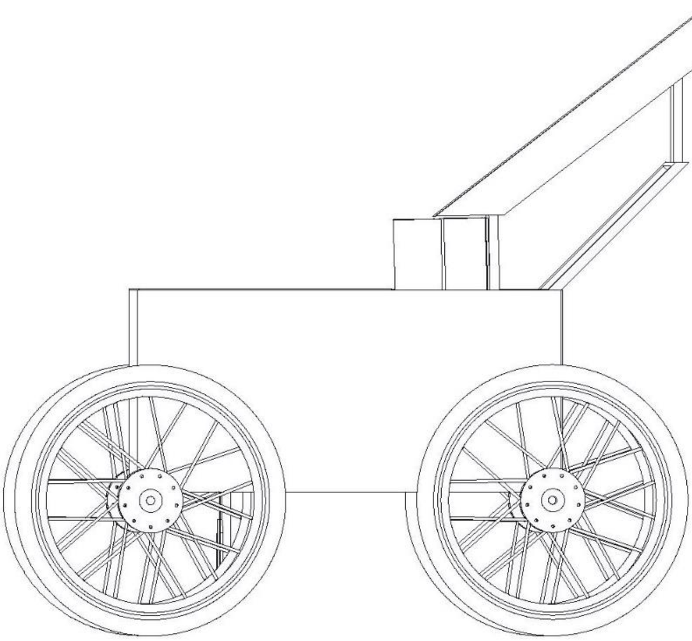


Figure 4.4 Side View Line diagram of the Machine

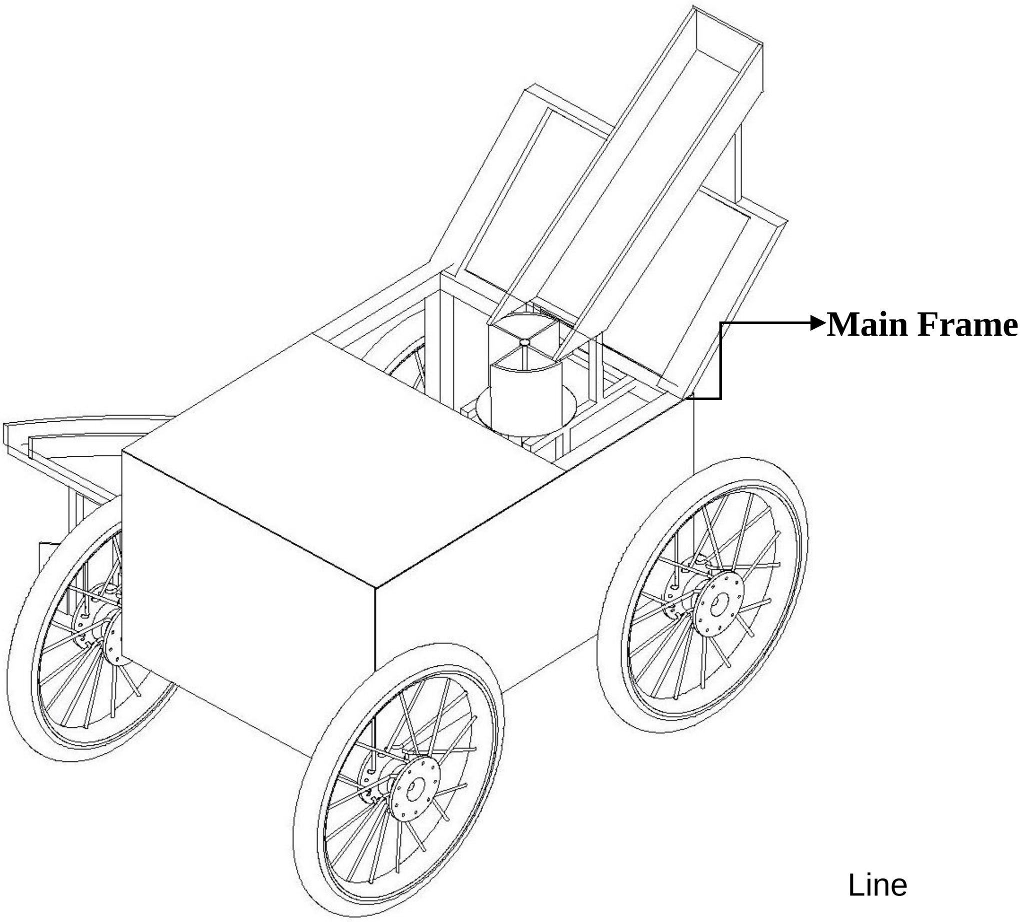


Figure 4.5: Isometric View Line diagram of the Machine

4.3 Design Calculations

4.3.1 Dimensions of the Machine:

- Length: 3 feet = 91.44 cm

- Width: 2 feet = 60.96 cm

- Height: 1.5 feet = 45.72 cm

- Wall thickness of mild steel pipes: 4x4 cm

- Density (kg/m^3) = 7850 kg/m^3

- Young's Modulus (GPa) = 200 GPa

4.3.2 Cross-Sectional Area of Mild Steel Pipes:

The cross-sectional area (A) = (Outer Width - Inner Width) * (Outer Height - Inner Height)

Where:

- Outer Width = 4 cm + 4 cm = 8 cm

- Inner Width = 4 cm

- Outer Height = 4 cm + 4 cm = 8 cm

- Inner Height = 4 cm

Substitution we have,

A = (8 - 4) * (8 - 4) = 4 * 4 = 16 cm^2

4.3.3 Moment of Inertia:

The moment of inertia (I) is needed to calculate the maximum bending stress. For a rectangular cross-section, the moment of inertia can be calculated as:

MOI (I) = $1/12*W*H^3$

Where:

- Width = Outer Width = 8 cm

- Height = Outer Height = 8 cm

Substitution We have,

$I = 1/12*8*8^3 = 341.33\ cm^4$

4.3.4 Bending Moment Calculation:

The bending moment (M) can be calculated using the formula: M = W *L/4

Where:

- W = Applied load = 13.5 kg (converted to Newtons)

- L = Length of the beam (considering the longest side of the cuboidal frame) = 3 feet = 0.9144 meters

$W = 13.5\ kg * 9.81\ m/s^2 = 132.435\ N$

Substitute the values:

M = (132.435 * 0.9144)/(4) = 30.375 Nm

4.3.5 Factor of Safety (FOS) Calculation:

The factor of safety (FOS) can be calculated using:

FOS = {Yield Strength} \ {Allowable Stress}

Since the yield strength of mild steel is estimated to be 275 MPa and we'll use an allowable stress of 0.6 times the yield strength

we have:

Allowable Stress = 0.6 * 275 MPa = 165 MPa

Substitute the values into the FOS formula:

FOS = 275 MPa/ 165 MPa = 1.6

4.3.6 Shear Stress Calculation:

The cross-sectional area (A) of each square pipe is (4*4) = 16 cm^2 = 0.0016 m^2

The shear stress (Ͳ) = {V}/{A}

Where (V) is the shear force calculated earlier (353.16 N) and (A) is the cross-sectional area of one pipe.

Substituting the values, we get

Ͳ = {353.16 N} / {0.0016 m^2} = 220725 Pa or 220.725 MPa.

4.3.7 Deflection Calculation:

Given the dimensions of the pipes and the applied load, we can calculate the moment of inertia \(I \) for each pipe using the formula for a square beam:

$I = b*d^3 /\{12\}$

Where:

b = d = 4 cm = 0.04 m (side length of the square pipe)

Substituting these values into the formula gives

$I = (0.04\ m) * (0.04\ m)^3 / \{12\} = 4.267 \times 10^{-7}\ m^4$

Now we can calculate the deflection (δ) using the formula:

$\delta = \{F * L^3\} / \{3*E*I\}$

Substituting the known values:

F = 36 * 9.81 N

L = 0.4572 m

E = 200 x 10^9 Pa (modulus of elasticity for mild steel)

I = 4.267 x 10^{-7} m^4

Substitution We get:

Δ = {36 * 9.81N * (0.4572 m^3)} / {3 * 200 x 10^9 Pa * 4.267 x10^{-7} m^4 = 0.0178 m = 1.78 cm

4.3.8 Yield Strength Calculation:

For the minimum yield strength of 250 MPa:

SF_{min}= 250 MPa / 220.725 MPa ≈1.13

For the maximum yield strength of 300 MPa:

SF_{max}= 300 MPa / 220.725 MPa ≈1.36

4.3.9 Stress Calculation:

Stress experienced by the mild steel pipes under the given loads. We can calculate the stress using the formula:

Stress = Force / Area

Given:

Force (load on the machine): 10 to 12 kgs

Area of the pipe: (A = bh), where (b) is the width of the pipe (4 cm) and (h) is the height of the pipe (also 4 cm) = 4 cm * 4 cm = 16 cm^2

Now, convert the load to Newtons if it's given in kilograms:

$Force_{min}$=10 kg x 9.81m/s^2 = 98.1N

Force $_{max}$=12 kg x 9.81 m/s^2 = 117.72N

Now, calculate the stress for both minimum and maximum loads:

Stress $_{min}$=98.1N / 16 cm^2 = 6.13 N/cm^2

Stress $_{max}$=117.72 N / 16 cm^2 = 7.36 N/cm^2

4.3.10 Torque Calculations:

Torque=Force X Distance

The force of 1200 N (Newton) and 0.72 meters (72 cm). Plugging these values into the formula:

Torque=1200 N×0.72 m = 864 Nm

4.3.11 Power Calculations of rotor:

Angular speed of the rortor = 90 rad/sec

Torque required (Ƭ) = 860 Nm

Substitution we have:

P = Ƭxw

P = 860X90 = 77.40 KW

MATERIAL SELECTION

For the tree plantation machine project, material selection is crucial for ensuring optimal performance and durability. The main frame, essential for structural integrity, benefits from steel alloys like carbon steel or stainless steel, offering high strength and corrosion resistance. Stainless steel is also ideal for components in contact with soil in the planting mechanism, ensuring longevity. Rubber tires provide traction and shock absorption in the machine's mobility system, while steel or reinforced plastic tracks offer stability in rough terrains. Control panels and enclosures benefit from powder-coated steel or aluminum for durability and weather resistance, with waterproofing for electronic components. Safety features utilize steel or impact-resistant plastics, ensuring operator protection, and copper wiring is preferred for electrical connections. Insulation and seals use rubber or silicone for moisture protection, and thermal insulation materials regulate temperature. These material choices collectively contribute to a robust and reliable tree plantation machine suitable for outdoor environments. Table 5.1 shows the material properties of the components.

5.1 Material Selections for the machine:

a. **Mild Steel (Carbon Steel):**

- **Strength**: Mild steel offers good strength properties, making it suitable for supporting the weight of the machine and resisting operational stresses.

- **Durability**: It is durable and can withstand heavy loads and impacts, ensuring the structural integrity of the main frame.

- **Cost-effectiveness**: Mild steel is cost-effective compared to some other materials, making it a practical choice for large structural components.

b. **Stainless Steel:**

- **Corrosion Resistance**: Stainless steel is highly resistant to corrosion, rust, and environmental degradation, ensuring longevity and durability in outdoor environments.

- **Aesthetic Appeal**: It has a polished finish and is aesthetically pleasing, which can be advantageous if appearance is a consideration.

- **Strength**: Stainless steel offers good strength properties, although it may be slightly less than mild steel in certain applications.

c. **Aluminium Alloy:**

- **Lightweight**: Aluminium alloys are significantly lighter than steel, which can contribute to overall weight reduction and improved mobility of the machine.

- **Corrosion Resistance**: Certain aluminium alloys offer good corrosion resistance, especially when properly coated or anodized for outdoor use.

- **Machinability:** Aluminium alloys are easier to machine compared to steel, allowing for intricate designs and customization in the main frame.

Table No.5.1: Material properties of Machine

Property	**Mild Steel (Carbon Steel)**	**Stainless Steel (304)**	**Aluminium Alloy (6061)**
Strength (MPa)	250 - 410	515 – 860	240 – 310
Density (kg/m³)	7850	7900	2700
Young's Modulus (GPa)	200	193	69
Yield Strength (MPa)	250 - 410	205 – 275	240 – 310
Corrosion Resistance	Low	High	Moderate to High
Weight (kg/m³)	7850	7900	2700
Cost	Cost-Effective	Moderate to High	Moderate to High
Machinability	Good	Moderate	Good

FABRICATION PROCESS

6.1 Material Procurement:

6.1.1 MILD STEEL:

- Mild steel, figure 6.1 also known as low carbon steel or plain carbon steel, is a type of carbon steel that contains a low amount of carbon (typically around 0.05% to 0.25%). Mild steel is a versatile material renowned for its favorable properties in various fabrication applications. Its strength, characterized by good tensile strength and toughness, renders it suitable for structural uses where high-strength alloys are not necessary.

- Additionally, mild steel boasts excellent ductility, allowing for easy forming, welding, and machining into diverse shapes and components. Its weldability, compatible with common techniques like arc, MIG, and TIG welding, enhances its utility in fabrication processes. Moreover, mild steel's machinability facilitates standard machining operations such as drilling, milling, and turning, ensuring ease during fabrication. While mild steel is susceptible to corrosion in certain environments, protective surface treatments like painting, galvanizing, or powder coating can effectively mitigate this issue, further enhancing its durability and longevity in practical applications.

Figure 6.1: Mild Steel Pipes

6.2 Fabrication process:

6.2.1 Laser Cutting process:

Laser cutting figure 6.2 is a highly precise and versatile manufacturing process used to cut various materials, including metals, plastics, and composites. Laser cutting stands out for its precision, achieving tight tolerances ideal for intricate designs and fine details crucial in high-accuracy projects. Laser cutting also promotes minimal waste due to narrow kerf widths, optimizing material usage, and leading to cost savings and environmental benefits. Furthermore, its automation capabilities, facilitated by CNC-controlled systems, ensure automated and repeatable cutting processes, guaranteeing consistency, efficiency, and scalability in production operations. Figure 6 shows laser cutting of Geneva mechanism to rotate. Figure 6.2 shows Laser cutting of the Geneva Mechanism.

Figure 6.2: Laser Cutting of Geneva

6.2.2 ARC Welding:

Arc welding is a widely utilized welding process that employs an electrical arc to fuse metals together. Its principle involves generating heat through the arc, melting the base metals to form a molten pool that solidifies into a strong weld joint upon cooling. Arc welding encompasses different techniques like Shielded Metal Arc Welding (SMAW). These include versatility in welding various metals, portability for on-site or outdoor applications, operator control over welding parameters, and cost-effectiveness in equipment and consumables. However, it requires proper safety precautions due to the intense heat and UV radiation involved, as well as skill and training to achieve high-quality welds. Figure 6.3 shows arc welding operations.

Figure 6.3: ARC Welding of the Frame

6.2.3 Machining Process:

Machining is a vital manufacturing process that involves shaping and finishing workpieces by removing material using cutting tools. It encompasses various techniques such as turning, milling, drilling, grinding, and more, each tailored to specific machining operations and workpiece requirements. Skilled operators and proper tool selection are crucial for achieving high-quality results, and advancements in machining technologies like CNC machining and automation have further enhanced precision, productivity, and customization in manufacturing processes. figure 6.4 and 6.5 shows Drilling hole in the main frame and Grinding of the main frame.

Figure 6.4: Drilling hole in the main frame

Figure 6.5: Grinding of the Main Frame

6.3 Components Used:

6.3.1 Worm Gear Motor:

A 12V worm gear motor is a compact and efficient electric motor that operates on a 12-volt DC power supply. It features a worm gear mechanism, consisting of a worm screw and a gear wheel, which provides a high reduction ratio and increased torque output. This makes it ideal for applications requiring controlled and reliable movement with high torque, such as robotics, automation systems, conveyor belts, and gate openers. These motors are designed for durability, with sealed construction for protection against environmental elements, and they offer various mounting options to suit different installation needs. Figure 6.6 shows worm gear motor.

- Function - Control, Speed Control
- Number of Poles- 2
- Structure and Working Principle - Brush
- Type - Worm Gear Box Reduction Motor
- Torque – 860 Nm
- Motor Size - 49mm 59mm 63mm 76mm 88mm
- Voltage - 12V
- Power – 78 KW
- Speed – 20 rpm.
- Material of Gear - MS
- Noise- Less 60dB
- Motor - High Torque Reversible Electric Motor

Figure 6.6: Worm Gear Motor

6.3.2 Battery:

A 15A high-power battery can deliver a continuous current of up to 15 amperes without overheating. It's commonly used in applications like electric vehicles, power tools, robotics, and renewable energy systems. These batteries provide a reliable power source for high-current demands, making them essential for various industries and electronic devices. Figure 6.7 shows 7.5A Battery.

Figure 6.7: 7.5A Battery

6.3.3 Geneva Model:

The Geneva drive is a mechanical mechanism used to convert continuous rotation into intermittent rotary motion. It consists of a driving wheel with a pin that engages with slots or teeth on a driven wheel. As the driving wheel rotates, the pin moves along the slots, causing the driven wheel to rotate intermittently. This mechanism is often used in applications such as indexing mechanisms, where precise intermittent motion is required, such as in clocks, camshafts, and conveyor systems. Figure 6.8 shows Geneva model.

Figure 6.8: Geneva

6.3.4 Speed Controller:

Electronic Spices PWM DC Motor Speed Controller 12V-40V 10A Module:

The Electronic Spices PWM DC Motor Speed Controller 12V-40V 10A

Module is a sophisticated device designed to regulate the speed of a DC motor efficiently. It incorporates a simple rotary potentiometer controller capable of handling DC motors up to 400 W, operating within a voltage range of 12 to 40 volts. Utilizing pulse-width modulation (PWM) technology, this controller offers a customizable duty cycle from 10% to 100%, effectively controlling the motor's speed and direction. With a maximum continuous current output of 8 amps, it ensures reliable performance and protection against over-voltage and reverse polarity, thanks to a built-in 10A fuse and robust circuitry. This controller is an economical yet powerful solution for linear speed variation of DC motors, providing high torque, minimal heat generation, and exceptional efficiency in various applications. Figure 6.9 shows the speed controller.

- Input supply voltage: - DC 12V-40V
- The maximum continuous output current: - 8A
- The maximum output power: - 400W
- PWM frequency: - 13kHz
- Weight: - 200 g

Figure 6.9: PWM Speed controller

6.3.5 DPDT Switch:

Double Pole Double Throw (DPDT switches are highly versatile electrical switches used in various applications due to their ability to control two separate circuits independently. They feature three positions: ON-ON, ON-OFF-ON, and OFF-ON, providing flexibility in circuit control. The dual control capability allows operators to manage different functionalities or operations separately, enhancing overall system functionality. DPDT switches are known for their simplicity, as their clear labeling and straightforward operation make them easy to use and understand. Despite their versatility, they maintain a compact design suitable for space-constrained applications and offer reliable performance over extended periods, making them a preferred choice for controlling motors, power sources, lighting circuits, and machinery with multiple functions in electrical and electronic systems. Figure 6.10 shows the DPDT Switch used in the project

- Current Rating - 20 Amps
- Switch Dimensions L=W=H=10cm
- Circuit Type 3-way
- Specifications 16A 250VAC

Figure 6.10: DPDT Switch

6.3.6 Rubber Tyres:

The tree plantation machine is equipped with 12-inch wheels Figure 6.11 chosen for their traction, stability, and maneuverability on various terrains. The wheels are designed to support the machine's weight and facilitate smooth movement during operation. A motorized drive system enables forward and reverse movement, controlled by the operator or automated functions.

Figure 6.11: Rubber tyre

6.3.7 Plywood:

We have used 5mm plywood Figure 6.12 to cover the main frame of your project and adds additional benefits specifically tailored to this application. In addition to the advantages previously mentioned, covering the main frame with 5mm plywood provides an extra layer of protection and aesthetic enhancement. It helps shield the main frame from environmental elements such as moisture, dust, and scratches, thereby prolonging its lifespan and maintaining its structural integrity. The plywood also contributes to the overall appearance of the project, offering a smooth and uniform surface that can be painted, stained, or finished to match the desired aesthetics.

Figure 6.12: Plywood

6.4 Assembly of Project:

Figure 6.13: Assembly of Model

The assembly of the project, figure 6.13 involves integrating various components and subsystems to create a functional and efficient tree plantation machine. The process begins with assembling the main frame using mild steel, ensuring structural integrity and stability. The 12-inch scooty tires are mounted onto the frame, providing mobility and traction for the machine. The motorized mechanism, controlled by an Electronic Spices PWM DC Motor Speed Controller 12V-40V 10A Module, is installed to regulate the speed and direction of the machine's movements.

Next, the planting mechanism, figure 6.14 is assembled, featuring a cup holder designed to pick and drop plant samplings. This mechanism is powered by the chosen 12V worm gear motor, delivering the necessary torque for precise and controlled sampling operations. The motor's torque output is calibrated to ensure efficient planting while minimizing energy consumption.

Additionally, the control system, consisting of DPDT switches and a user-friendly interface figure 6.15 is integrated to provide operators with seamless control over the machine's functions. The plywood cover, with a thickness of 5mm, is then installed to enclose and protect the internal components while maintaining accessibility for maintenance and troubleshooting.

Figure 6.14: Working Mechanism of Model   Figure 6.15: Prototype of the Machine

Result And Discussion

The results were discussed through the principal operation of the designed machine prototype shown in Figure 6.15. The first step in planting is land preparation. Preparing raw land before planting the seedlings is essential. It can make a huge difference in the seedlings' growing quality. The preparation includes removing any obstacles in the way of plants while growing and help ventilate the

soil before planting.

Figure 7.1: Front view and Side view of Working Model

The second step-in farming is processing. The planting machine should be linked tightly with a driving vehicle such as a farm tractor, a robot, or even the machine itself without the need for any vehicles. Then, the seedlings will be filled from the seedlings tray to the machine slots. The first step of the operation started by dropping the pneumatic cylinder that connected to the wheel's shaft.

Finally, the machine runs to plant the whole field figure 7.1 Even the authors did not plat a huge area since it is a prototype sample, the machine showed some effective results and smooth sowing. Note that the machine starts planting after lowering the end of the machine to get the plowers to the ground.

The Working procedure as follows:

(1) The shaft of the wheel will contain a circular disk as shown in Figure 15 When the disk rotates, the sampling will fall on to the cup like structure which is been controlled by manual switches. The number of revolutions will control the number of transmitted signals. Figure 7.1 shows how the sensor takes signals from the wheel.
(2) The transmit seedling belt linked between stepper motors and shaft. It manages the seedlings that slip in the plate’s slot by its weight. Besides manages them before slipping into the transverse pyramid by signals from proximity sensors as shown in figure 7.1.
(3) The transmit seedling belt linked between stepper motors and shaft. It manages the seedlings that slip in the plate’s slot by its weight. Besides manages them before slipping into the transverse pyramid by signals from proximity sensors as shown in figure 7.1.
(4) Before each transverse pyramid, there is a plow leg digs a hole along the line path where seedlings will fall. The main purpose of this part is to keep the soil away from the planting path as shown in figure 7.1.
(5) After plowing, there are cones (transverse pyramids) with an oblong shape. These cones drive the seedling from the plate straight to the hole in the ground and prevent the seedling.
(6) Here comes the role of sanders. The sanders landfill the seedling by aggregation the soil around the seedlings.

In general, the current porotype machine showed acceptable results in planting. All the operation steps worked smoothly as proposed. This research will be a hand for all keen researchers and farmers in the field. Moreover, the proposed porotype costs less than a thousand USD since the cost is an important issue when designing a planter [7]. Compared to the previous research papers, the planting machine does not need workers as in [3, 5, 9, 10, 12, 13, 14, 24, 26]. It can also be applied on land even as a prototype compared to other machines [27] or when they are functioned by robotic systems [13, 27]. Note that most of the machines are for seeds and there is an obvious lack of planting transplant machines. Some of them are for special kinds of seeds or plants and most of them just show the main mechanism.

The implementation of our automated tree planting machine has yielded significant advantages over manual labour in terms of cost savings, efficiency, and environmental impact. Through meticulous calculations and analysis, we have determined that our machine is capable of planting one tree every 30 to 35 seconds, whereas manual labour requires approximately a minute and a half per tree. This translates to substantial time savings, reducing the labour cost per tree planted to around 850 rupees. Over a day's work, with the capacity to plant 400 saplings, this results in a significant reduction in labour expenses, especially when factoring in food and transportation costs for manual labourers.

Furthermore, the upfront cost of the automated tree planting machine, estimated at 30,000 to 35,000 rupees, is a worthwhile investment considering the long-term benefits. The machine's efficiency not only saves time and labour costs but also ensures precise and uniform planting, contributing to higher survival rates and healthier trees compared to manual methods. Our calculations indicate a potential cost savings of up to 30% or more when using the machine, making it a cost-effective solution for large-scale tree planting projects.

In addition to financial gains, the environmental impact of our machine is noteworthy. By reducing soil disturbances and conserving resources, such as water and energy, our automated planting process promotes sustainable forestry practices. The machine's operational efficiency, ease of use, and adaptability to various planting conditions further enhance its value and applicability in different environments.

Looking ahead, our project underscores the importance of continuous improvement and innovation in automated technologies for forestry and agriculture. Future enhancements may focus on optimizing sensor technology, fine-tuning planting mechanisms for different soil types, and integrating advanced data analytics for real-time monitoring and decision-making. By addressing these areas, we aim to further enhance the machine's performance, maximize cost savings, and contribute to sustainable land management practices.

Overall, our results demonstrate that automated tree planting machines offer a viable and efficient alternative to manual labour, providing substantial cost savings, improved productivity, and positive environmental outcomes.

COST ANALYSIS

The cost analysis for the tree plantation machine project encompasses various aspects, including material costs, labor costs, equipment costs, and operational expenses. A detailed breakdown of these costs is essential for assessing the project's financial feasibility and budgeting effectively**.**

On an average labour cost of 100 rupees for planting 1 sapling and 100 saplings per day including food and transportation charges:

1. **Time Saved per Tree:**

Time saved per tree = 1800 sec (30 minutes) (manual labor time) – 300 sec (5 minutes) (machine time)

2. **Time Saved for 400 Saplings:**

Time saved for 400 saplings = Time saved per tree * Number of saplings = 30 minutes/tree * 400 trees = 720,000 seconds/day = 200 hours

3. **Cost Savings per Day**:

Total time saved per tree = 1500 seconds = 25 min per tree

Labor cost per day = 500 rupees

Cost savings per day = Labor cost per day * Total time saved = 500 rupees per day * 25 minutes = 12,500/- rupees/day

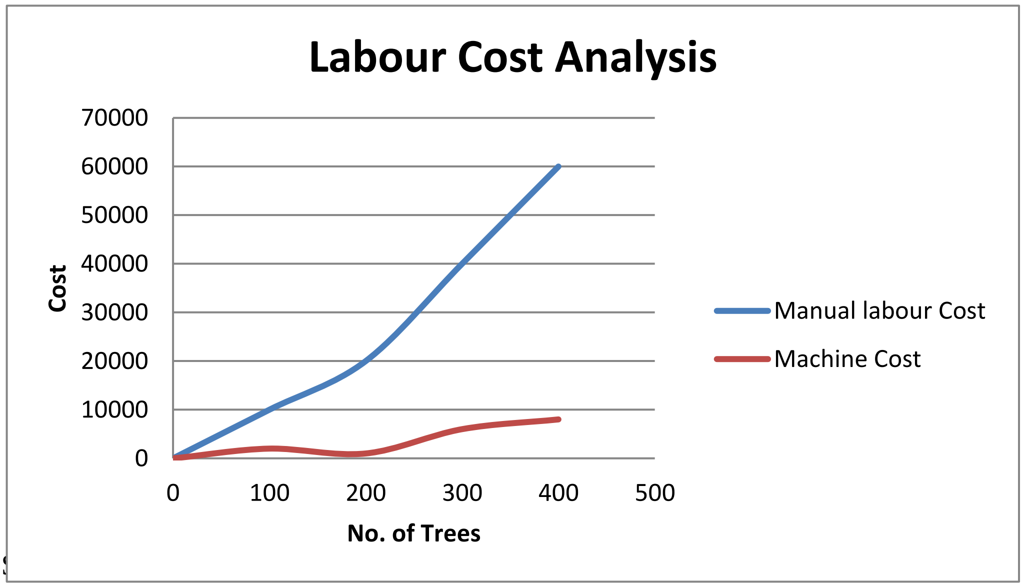


Figure 8.1: Labor cost

estimation of tree plantation

Figure 8.1 shows cost estimation of tree plantation labor per plant and this cost was calculated for 400 plants.

Manual labor per plants is estimated as Rs 100 and using machine cost of plant planted is Rs 20. By this calculation it is notice that cost of each plants saves Rs 80 and 80% of amount will be saved using tree plantation machine.

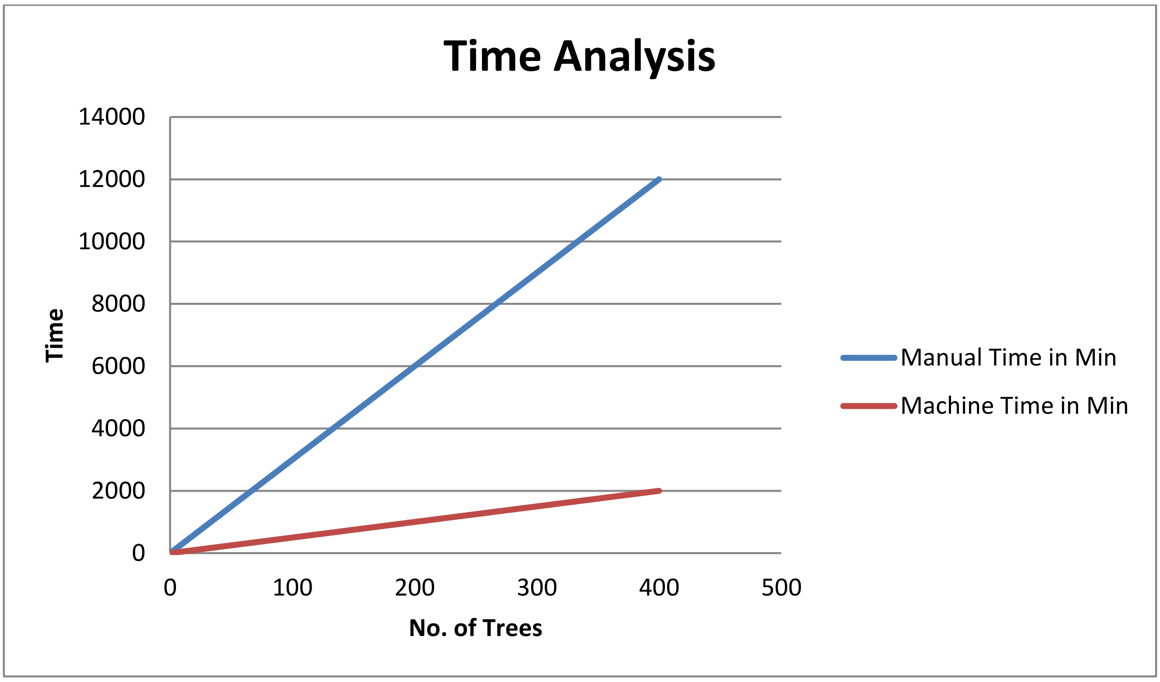


Figure 8.2: Labor Time estimation of tree plantation

Figure 8.1 and 8.2 shows time estimation of tree plantation time taken by this calculation it is notice that time taken of each plant 5 min in the machine and 30 min time was taken by manual labor to plant per tree.

Table 8.1: Labor Time in Minutes

No. of Plants	Manual Time in Min	Machine Time in Min
1	30	5
100	3000	500
200	6000	1000
300	9000	1500
400	12000	2000

Table 8.2: Cost Analysis

S.No	Particulars	Amount
1	MAIN BASE (Chasi with a four wheel tyres)	10000
2	Geneva and Disc Components, Main Frame	10000
3	Worm Gear motors and battery, Speed Controller	9000
4	Labor Cost	2000
5	Miscellaneous	2000
Total Cost of the Project		Rs. 33000/-

LIST OF TECHNICAL OUTCOMES

1. **Precise Planting**: The machine achieves precise planting of tree saplings at regular intervals due to the controlled motor-driven planting mechanism and the intermittent motion provided by the Geneva mechanism.

2. **Uniform Spacing**: The Geneva mechanism ensures uniform spacing between planted saplings, contributing to optimal growth conditions and efficient land utilization.

3. **Efficient Motor Control**: The motor control system, operated by switches, allows for efficient and accurate control of the machine's movements, including cup positioning and planting depth.

4. **Consistent Planting Depth**: The machine consistently plants saplings at the desired depth, promoting uniform root development and plant stability.

5. **Increased Productivity**: Compared to manual planting methods, the machine significantly increases productivity by automating the planting process, reducing labor requirements, and enabling faster tree plantation.

6. **Reliability:** The machine demonstrates reliable performance during testing and operation, with minimal downtime or malfunctions, ensuring continuous and efficient tree planting operations.

7. **User-Friendly Interface**: The switch-based control system provides a user-friendly interface for operators, allowing for easy operation and adjustment of machine parameters.

8. **Optimized Resource Utilization**: By precisely controlling planting depth, spacing, and timing, the machine optimizes resource utilization, such as soil nutrients, water, and land area, leading to improved plant growth outcomes.

9. **Scalability**: The design and functionality of the machine allow for scalability to accommodate various plantation sizes and environments, from small-scale projects to large-scale reforestation efforts.

10. **Adaptive Planting:** The machine demonstrates adaptability to various soil types and terrains, ensuring successful planting across diverse environmental conditions, from flatlands to rugged terrains.

11. **Real-time Monitoring**: Leveraging sensors and IoT technology, the machine enables real-time monitoring of planting activities, offering valuable insights into soil health, planting progress, and environmental factors for informed decision-making.

12. **Energy-efficient Operations**: Through the integration of low-power components and optimized motor control algorithms, the machine prioritizes energy efficiency, minimizing power consumption and reducing its environmental footprint.

13. **Remote Operation Capability**: Integrated remote-control systems empower operators to oversee and manage the machine's operations from a distance, enhancing operational flexibility and enabling efficient management of large-scale plantation projects.

14. **Modular Maintenance**: With a modular design approach, the machine facilitates ease of maintenance, repairs, and upgrades, ensuring prolonged functionality and adaptability to future technological advancements and project requirements.

Conclusion And Future Work

10.1 Conclusion

The existing research presents a Semi-automatic controlled planting machine. Investing in agriculture filed is crucial due to the importance of planting in human life. Over the years, several machines were invented in many sectors, like a tractor in traction and power, the plow in soil cultivation, spreader in fertilizing, and center pivot irrigation in irrigation and planting. The current machine is a prototype to serve this sector. It can fulfill the need and suit people in developed countries. The results showed a great functioning in which the machine can work efficiently and smoothly. The accuracy was reasonable and this machine can do the basic job in planting.

1. The tree plantation machine, integrating motor-controlled mechanisms and the Geneva mechanism, demonstrated precise and efficient sapling planting.
2. Significant productivity gains were achieved compared to manual methods, reducing labor requirements and time for planting tasks.
3. The machine's user-friendly interface, operated by switches, ensures ease of operation and parameter adjustment.
4. Reliability and durability were observed throughout testing, with minimal downtime or malfunctions, ensuring continuous operation.
5. Environmental benefits include optimized resource utilization, contributing to sustainable land management and reforestation efforts.
6. Future enhancements may focus on automation, sensor integration for data collection, and scalability for diverse plantation environments.
7. Collaboration across disciplines underscores the importance of interdisciplinary approaches in addressing environmental challenges.
8. The project's impact lies in its potential to revolutionize tree planting practices and support global sustainability initiatives.

Future Work

1. It can be developed for forest plantation.
2. It can be developed for automated plantation machine using IoT.

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