"DEVELOPMENT OF INTERNET BASED SMART AGRICULTURAL RESOURCE SHARING FRAMEWORK"

A Thesis

Submitted in partial fulfillment of the requirements for the

Award of the degree of

DOCTOR OF PHILOSOPHY

In

COMPUTER SCIENCE AND ENGINEERING

By

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PUNJAB

2021

DECLARATION

I, Manik, declare that this thesis titled, "Development of Internet Based Smart Agricultural Resource Sharing Framework" and the work presented in it are my own. I confirm that:

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ABSTRACT

India is an agricultural country and it has made rapid strides in the field of agriculture through the use of machinery. A lot needs to be done in this direction to boost the agricultural economy. Punjab, which is primarily an agrarian state, has fed the country for a long. It has been known as the food basket of India. Its contribution to the Indian food grain basket is 13%, which emphasizes the fact that agricultural operations across India require automation to increase agriculture production. There are obstacles in the way of the automation of agriculture. Though modern cutting-edge technologies are better, they come at a high cost. The use of such expensive technologies often lands farmers into a vicious cycle of debt besides forcing them to commit suicide. Many natural, geographical and socio-economic and political events also make the lives of the farmers miserable and push them into a debt trap, which often results in suicides. Yet, it is an undeniable fact that mechanized farming plays a critical role in addressing these issues. Agriculture mechanization focuses on the utilization of various machines expediently and proficiently in farming operations with an aim to relieving the farmers from the burden of physical work and debt. Custom hiring center is a new idea in farming that aims to make easier for like-minded farmers to embrace technology/ machinery for better resource management practices. The study in question focuses on the need for renting and sharing of tools and equipment. Renting and sharing is a potential strategy that enables farmers to borrow equipment at a reasonable cost rather than purchasing them. Herein, a pilot study of 562 farmers in India has been done manually to address the various issues faced by the farmers in searching tools and equipment and also to explore their keen interest in the process of renting and sharing the equipment. This survey falls under different categories: small, medium and large farmers. The dataset of the survey conducted was normalized to remove the ambiguity and on the same dataset trained and a testing split was applied to understand the target variables. Three different Machine learning models namely, KNearest Neighbors, Logistic Regression, Decision Trees were applied. To get the optimized result, a comparative study of the mentioned algorithm models was done which, in turn, revealed that the decision tree is the best model among the other models. Since the decision tree model is entirely

based on various input parameters like the kind of crop, time/month of harvest and kind of equipment needed for the crops, it has the potential to impact farmers both socially and economically. Based on the searching of tools and equipment by the farmers, an optimized recommendation engine is embedded in the system that provides recommendations. The concept of content and collaborative-based filtering is used in the model. Price is determined by supply and demand in the market. Therefore, demand and supply algorithms are used to explain market equilibrium and also to anticipate weather fluctuations in the peak season. To predict the price of a tool and the accuracy of the model, a static dataset is used. After training and evaluating various models on the training and testing dataset, we found that Decisions Trees performed the best with a mean absolute error of 138.33. Hence, we have chosen Decision Tree Regressor as our optimal model. The farmers will be able to uplift their agricultural practices and production through intelligent e-marketplace crowdsourcing. To further help farmers, we have designed an Internet-based mobile application that can be used to promote reserve, rent, and share agricultural equipment.

ACKNOWLEDGMENTS

First of all, I pay my gratitude to the Almighty for conceding me an opportunity and strength to successfully accomplish this assignment.

I would like to thank my esteemed supervisor – **Dr. Ramandeep Singh** for his invaluable supervision, support and tutelage during the course of my Ph.D degree. I owe my deep sense of gratitude to the dynamic academician and generous guide, who all along has been an immense source of encouragement to me in completing this work. They really spared time for academic interaction with me. There is a logical way of thinking as a true experimentalist provided a good basis for future endeavors.

My heartfelt gratitude and indebtedness go to my loving parents **(Sh. Avinash Chander and Madhu Bala)** for their blessings, encouragement, and assistance. The efforts of my Wife and sister **(Dr. Neha Verma and Sakshi)** deserve great appreciation for understanding and cooperation.

Finally, I very sincerely acknowledge the cooperation of my respected Supervisors who helped me a lot during this work. I am thankful to all respected HOD **Dalwinder Singh** and dear friends **Dr. Mohammad shabaz, Dr.Jimmy Singla, Mohit Arora, kapil jairath,** for timely help and friendly guidance. I would like to thank all the authors whose studies have been quoted in this study.

Manik Rakhra

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LIST OF ABBREVIATIONS

TFP	:	Total Factor Productivity
HYV	:	High Yield Variety
CHC	:	Custom Hiring Centres
VCRMC	:	Village Climate Risk Management Committee
AI	:	Artificial Intelligence
IOT	:	Internet of Things
GPS	:	Global Positioning System
ML	:	Machine Learning
ANN	:	Artificial Neural Network
SDO	:	Supply-Demand Optimization
FPR	:	False Positive Rate
TPR	:	True Positive Rate
ROC	:	Receiver Operating Curve

Chapter – 1

INTRODUCTION

India is an agriculture-based country and, here a significant agricultural progress has been made via the use of machines. With mechanized farming, India has been able to feed its population. Yet, a glaring mismatch exists between food production and its beneficiaries. This issue does not trouble India alone, it is a global issue. As per a report, by 2051, we will have to sustain over 10 billion individuals, which would require 70% expansion in the worldwide production of food products [1]. To address the huge challenge of making food grains available to all on this planet, farming operations need to undergo a drastic change. They need to be aided and supported by machines. Yet, a large number of farmers on the planet who are engaged in the task of food grain production still do not have access to tools and current innovations [2]. Owing to little landholdings and credit limitations, in many countries farmers have not been able to channelize their resources in a way that help them build efficiency and boost agriculture production [3].

However, the progressive farmers that exploit innovative farming methods reap the maximum benefits in terms of bumper yield and money. Innovative agriculture practices also lead to cost reduction besides providing quality food grains with more ecologically friendly procedures [4]. However, taking these benefits to the farm will rely on farmers willingness to use modern technology in their fields [5,6]. It is therefore imperative to motivate farmers to embrace latest tools and technology to achieve twin goals of meeting increased food demand and profitability.

In Punjab, the agriculture scenario is grim. Several factors contribute to it. According to several polls, 65% of Punjab's farmers hold 1-4 hectares (or 1 hectare = 2.5 acres) of land. Only 7% of landowners possess 10+ hectares [7]. According to a socio-economic and census analysis, the proportion of rural families in Punjab without land is among the highest in the nation. Since farmers lease their landholdings in Punjab, the size of farmland is decreasing. Consequently, it is badly impacting production and profitability [8]. Climate changes (erratic and irregular monsoon) also affect financial position /situation of farmers. These changes often lead to a variable pricing of agricultural products. Punjab has been facing the ugly problem of rising farm debts for decades. This has led to another problem of farmers suicide in the state . The state is badly in its grip. Conspicuous consumer culture, depleting water resources and arbitrary farm policies have further given a blow to the farming community in the state.

Among all the factors, rural indebtedness tops the list. In Punjab, 86% of farming households were under debt; between 2000-2015, more than 16 thousand farmers died by suicide for not being able to repay loans [9]. Nearly 1,100 farmers in Punjab end their lives each year owing to the weight of debt. This data supports the 2020 report in which many districts in Malwa have experienced the severest blow of farm indebtedness [10].

The farmer suicide rate is increasing day by day in India. This calls for mechanization of farming operations. Besides, modern data-based agriculture positively impacts the farming operations. It also provides a sustainable and profitable livelihood without doing any irreparable damage to environment. However, automation further provides directions, how to properly analyze modern agriculture's role in sustainable decision-making [11]. Thus, the overall view depicts that there is a real need of renting and sharing of tools and equipment that will be beneficial for all categories of farmers, be it small, medium and large.

1.1 FARM MECHANIZATION

In India, only around 30% of farmland is fully mechanized. Nearly 75% of farmers own 1 hectare or less land hectare of land [12]. With such small landholdings, farmers do not buy their own equipment. Farmers face a plethora of other difficulties which among others include: limited access to creditors, high prices, unreliable transportation et al. Farm machines such as tractors are often costly and it is always beyond the means of small and medium-scale farmers to acquire them. Consequently, these machines are borrowed on rent and farmers have to pay unfair rent to their owners during the peak season. Unavailability of machinery during the peak season is another issue that plagues the farmers. Although agricultural machinery is not very highly priced, a big chunk of farmers cannot afford it. Besides, many initiatives to mechanize agricultural operations have centered on the deployment of tractors, completely neglecting other crucial farming equipment.

Renting and sharing is a potential key that enables farmers to borrow equipment at a reasonable cost rather than purchasing the tool [13-16]. It also allows the agriculturist to be more adaptable in cultivating activities that aid in various crop cycles. Agribusiness is well-known for its activity and growth. At the moment, Punjab contributes 13% in Indian food production. Punjab supplies 24 percent of India's total wheat while the total rice output is pegged at 14 percent [17]. Farm mechanization in Punjab (agribusiness) has played a significant role in the rapid transformation of crop cultivation techniques [18]. A more aggressive action in this department can give impetus to agribusiness in Punjab, especially in the increase of crop yield. Hence, farm automation is a realistic solution. While substantial contribution has been made by automation to the expansion of the nation's agricultural sector, a lot more is still need to be done. Farmers with low assets have not been attracted to the fold mechanization of farming [19]. Small farmers have to employ machinery to do specialized jobs. They use machine for ploughing only as they are constrained by time. Unseasonal rains further spoils their dreams.

Mechanization focuses on using various sources of power while improved farm equipment focuses on shortening the workload, increasing the effectiveness of exploiting agricultural inputs and reducing yield loss at various production phases [20]. Farm mechanization aims to boost economic productivity and output while limiting production costs. Agricultural mechanization helps increase the yield of crops and it is aided by irrigation, biological and chemical inputs. Fertilizers, pesticides, and mechanical energy play their critical roles [21-23]. Thus it can be concluded that a machine can do more work than thousand hands employed can do and also with better efficiency.

Additionally, the human labour capacity is far lower than that of technology. A typical human worker can do work equivalent to roughly 0.9 horsepower (2.3 mega joules per hour). A machine can significantly perform better than human efforts. Thus, it is established beyond doubt that farm automation is far superior to physical labour and can provide better opportunities to the farmers.

1.1.1 Ways in which Agricultural Productivity can be Measured?

Productivity is often assessed in terms of market norms. Total factor productivity (TFP) measures agricultural productivity as the ratio of agricultural outputs to inputs [24,25]. As a result, agricultural productivity is often assessed as the market value of the finished product. This productivity may be compared to a variety of inputs, including labor and land. Mechanization and High Yield Variety (HYV) seeds, which may yield up to 10 times more crops than conventional seeds on the same amount of land, as well as fertilizers and animal feeds, are the sources of agricultural production [26].

1.1.2 Need and Benefits of Hiring and Renting farming Equipment and Tools

Hiring and renting of tools is an essential parameter for carrying out farming operations .There is a need to encourage rental facilities for small and medium farmers because everyday farming operations depend completely on equipment. Farmers are endowed with many benefits when they give their land on lease . Timely harvest and reduced instalments on equipment to be paid to the bank or commission agents are the two major benefits that farmers reap [27]. The leasing system offers landowners an opportunity to increase production quickly. Losing one day of labor may have considerable effects since agriculture is so time-sensitive. Farmers depend upon the borrowed money taken from the commission agent to buy the necessary equipment. They pay the high rate of interest on the loan that they borrow. This is a sensitive issue and it can be controlled by using the concept of renting and sharing [28]. The lease cost is substantially lower than the loan, making it easier for smaller and local producers to pay off the debt. In addition to it, farmers who hire the tool may negotiate more credit facilities and make fewer payments through leasing [29, 30]. Leasing enables farmers to experiment with technology without buying it first.

Furthermore, quick use of machinery does not need ownership. Farmers may frequently rent out equipment to their neighbours or provide contracting services to them if the necessity arises through community groups, cooperatives and non-profit organizations. On the other hand, leasing equipment is often utilized for shorter durations, giving farmers access to the newest technology. Moreover, in the process, it allows farmers to experience first-hand changes in their chosen fields [31].

Borrowing money to invest in equipment which benefit the farmers in carrying out farm operations burdens farmers [32]. The unexpected rain can spoil one-quarter of wheat harvest. For those small and marginal farmers with 1 to 2 hectares of land, the average investment in tractors, threshers, seeders, rotators, and reapers is eight times their yearly earnings. This leads to a huge loss to the farmers who chose to go for mechanized farmimg.

Thus, the alternative to farmers, typically with small landholdings and limited money, is to access quality equipment and machines either on an hourly or daily basis. This helps them save on heavy investments besides relieving them of financial burden [33]. On the other side, renting out assets can help the owner generate additional revenue.

1.2 CUSTOM HIRING

Custom hiring centers is a novel concept in farming that intends to stimulate the adoption of improved resource management strategies. These resource-sharing techniques at a cheaper cost to individual farmers are prevalent in some specific parts of the country. Under this innovative programme/ strategy, agricultural equipment and tools are shared with the farming community [34]. Custom hiring centers enable needy farmers to gain the advantages of automation via the utilization of costly equipment. Some cooperative organizations have taken the initiative to offer agricultural equipment services to farming community.

The role of tractor in farming is undoubtedly immense. But studies revealed that that a tractor was used for an average of two hours each day to carry out farming operations. In a developed village in Punjab, rented out tractor hours amount to 76 hours per year, and ploughing account for 61% of those hours. Thus it is concluded that a farmer might run his farm with the help of custom-hired tools [35-36]. Farmers with less than 2.8 hectare of land are prospective consumers of agricultural tools via hiring/rental services. The state's mechanization level has also expanded dramatically. CHCs have thus played a major role in popularizing mechanized farming among farmers. CHCs make farm tools, machinery and equipment available to farmers on a rental basis [37-38]. While specific tools and equipment (power units, tractors, tillers and harvesters) are crop-specific and are universally employed, practices of resource sharing, mainly farm machinery and implements at a reduced cost to individual farmers are trends in some regions of the country. Figure 1.1 displays a cycle of agricultural mechanisms that are under development.

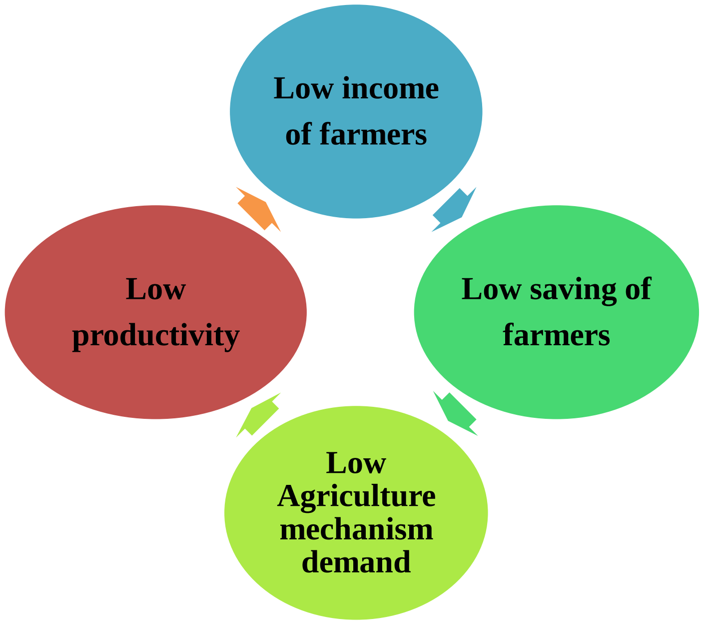


Figure 1.1: Various Cycle of Agriculture Mechanism under Development

Mechanization introduces accuracy and timeliness into agricultural activities, higher field covering over a shorter period of time, resource consumption, conservation of moisture content under stressful conditions, and supply of proper drainage [39]. In 100 NICRA communities custom hiring centres (CHCs), farm tools are built, enabling farmers to overcome labour shortages and increase agricultural productivity. The custom hiring center is managed by a panel of farmers appointed by the Panchayati Raj. The Village Climate and Risk Management Committee determines the fees for renting the machines/implements (VCRMC). Additionally, this committee utilizes the cash earned by hiring costs to repair and maintain tools, with the remaining amount going into various the financing schemes meant for the farmers. Custom Hiring empowers small and marginal farmers to make use of expensive agricultural equipment. It enables farmers to operate expensive techniques and technology and complete the harvesting task in a short span of time. Also, it cuts labour and boosts crop intensity. [40-41].

Custom hiring is not a cumbersome programme/ strategy. It does not burden farmers. Under the programme, the user only needs to pay the contract/rental charges and security. Each model has been designed to determine the best hardware and asset assignment to reduce farming costs and convenience. The model is designed to choose appropriate agricultural tools and power sources with the purpose of accomplishing the task on time. This eliminates the shortage of produce, which is otherwise a consequence of delayed agricultural operations. The operationalization of asset assignment programme in the year 2007 to minimize the cost turned out to be a success. Consequently, more analysis was performed on supply chain measures and financial productivity in Punjab.

The small farmers saw their financial productivity to go up by 17.02%, but large farmers displayed much higher economic productivity. The larger farmers have access to superior equipment. The smaller farmers cannot afford it. Yet, mechanized farming pays to the smaller farmers. About 90% of the farmers in Punjab who own tractors use them less than 400 hours annually [42]. Mechanization in this scenario plays a big role as it boosts growth. Custom hiring centres should pitch in here (They are already doing it) to make farming tools and equipment available to the small farmers at the appropriate time to get the intended results. This would mitigate the loan burden for the farmers as they usually borrow loans at high rate of interest from commission agents [43].

Farmers often spend between 25 to 30 percent of their revenues on the purchase of equipment. Since these equipment are purchased from the local entrepreneurs at expensive prices, they increase the farming input cost. Labour is also hard to come by in Punjab as the rural population often migrate to cities in search of better employment avenues. In such a grim scenario, the role of mechanized farming assisted by CHCs increases manifold. This can accelerate agriculture growth; boost economy and also allow the Indian market to grow. This also has the potential to end the protracted issue of rural indebtedness and low profitability besides retaining small farmers in the agriculture business.

Over 20 crores Indian farmers lack access to agricultural equipment and many of them have not even used them. Yet, small farmers who own 86 percent of India's farmland are doing their best to transform agriculture production and revenue dramatically [44].

According to a report by NCRB, around 97 percent of suicides in the Malwa region were triggered by "agricultural debt." The bulk of unfortunate among them are small and marginal farmers, who own between one and five acres of land. Around 2.55 percent of farmers in the Majha and Doaba areas commit suicide. Of these suicides 1.81 percent are linked to agricultural debt [45]. The economic condition of small/marginal farmers is quite weak and they cannot acquire agricultural equipment on their own or via institutional finance. To tide over the situation, custom hiring centers are established for small/marginal landowners to access agricultural equipment.

1.3 ISSUES THAT FORCE FARMERS TO FACE DEATH

Farmers commit suicide to take the extreme step for putting their life to an end for innumerable reasons. Floods, famines, indebtedness, geographical remoteness, loss in productivity, distress sale, inability to pay off debt and many more factors push farmers to the wall, which often results in suicides. A host of other factors like illness, climate change, illogical national policy on agriculture also compel farmers to take resort to suicide. The inability of the farmers to pay off the debts borrowed from the bank/ commission agents often acts as a trigger and force them to end their life. The mismatch between input cost and net profit is so skewed that it frustrates farmers beyond repair, which finally gets culminated in their death. As their revenue goes down farmers are left with no other alternative except to commit suicide. Of late, media highlighted the significant spike in farmers' deaths in Punjab. This unfortunate trend of farmers suicide is attributed to restructuring of the agricultural system, crop failure, especially cotton in recent times, mounting debt, and joblessness [46]. The media report calls for a deep introspection of agriculture related laws besides looking for other causes that push farmers to death trap. In order to find out the factors/ causes that induce farmers to suicide in Punjab, this research study was performed.

1.3.1 Suicide Loss Overview

A check at the agricultural suicide profile revealed that small and marginal farmers with land ownership of up to five acres were more prone to suicides. These farmers of Malwa belt of Punjab [47] would acquire extra land on lease at the cost of Rs 30,000-40,000 per year. These small and marginal farmers accounted for 70-80% of farmers suicides in the government records.

In the present era, Farmer's financial burden is increased by routine fixed expenses such as the maintenance and depth of submersible pumps that costs in lakhs. Making such investments is financially unfeasible for a small or marginal farmer, so they borrow from informal sources for which they have to exorbitant rate of interest (18 to 36 per cent). Therefore, in this study, we are going to design a intelligent decision support system. Through this system, the user who wants to give his equipment on lease can update the data on the framework, and the end user, who is in search of tool, can get the right equipment at the right time. With this framework, the different farmers who live in provincial zones get updated about the new innovation. Thus by using them, can save their crops from ruins and disasters. This system will help farmers get their crops harvested in peak time without any fear of non-availability of equipment. This framework will help the farmers by getting login into the framework and by accessibility of the needed equipment. Once a farmer gets accessibility to the correct asset, he has to pay the sum for taking the tool on rent/lease for a specific time. By this way, a farmer's dependency on banks/ commission agents for borrowing loan will end. This proposed framework, in turn, will enhance the financial strength of farmers.

1.3.2 Exploitation by Commission Agent (Arhtiyas)

Many farmers with no other income other than agriculture depend on loan to build farm infrastructure and also to sustain their daily agriculture operations. Since Cooperative societies provide short-term official loans for seasonal agricultural needs and do not lend loans for other agri based operations, including loan against leased land, farmers borrow loan from commission agents. These loans are borrowed at high rate of interest [41-45].

1.4 THE ROLE OF AGRICULTURAL MECHANIZATION IN EMERGING REGIONS

This section is aimed at highlighting a broad range of automation in agriculture. The part of this study also highlights the significant roles that precision farming plays in influencing the farm productivity and production with its wide use in agricultural activities. Farm mechanization not only maximizes the use of resources such as land, labour and water, but it also saves time. It also eliminates drudgery for farmers. Thus, the efficient use of time, labour and energy often leads to multi-cropping and timely planting of crops which, in turn, results in higher productivity.

1.4.1 Concept of Agricultural Mechanization

Farm modernization has been described in many ways. It denotes utilization of machines, technology, and machinery used in agriculture operations to boost production and crop yield. Mechanization has three basic renewable resources: human power, chemical fertilizers, and mechanical effort.

Early and essential stages of agricultural mechanization include using human power for making hand tools and equipment. Animal muscle power is used to operate farm equipment and implements. However, there is a substantial difference in sources of energy being used across countries for carrying out agriculture related operations. And, these sources of energy range from renewable to non-renewable. The concept of sustainable agriculture, however, lies in the use of machinery in farm development activities in a way that environment should not be damaged [48]. Mechanization ensures that agricultural tools are eco-friendly, financially accessible, adaptive to local circumstances, and robust in terms of changing weather patterns and climate. Use of mechanical power sources and equipment are key determinants of mechanization. Mechanization, on the other hand, denotes the degree to which a crop producing activity is automated.

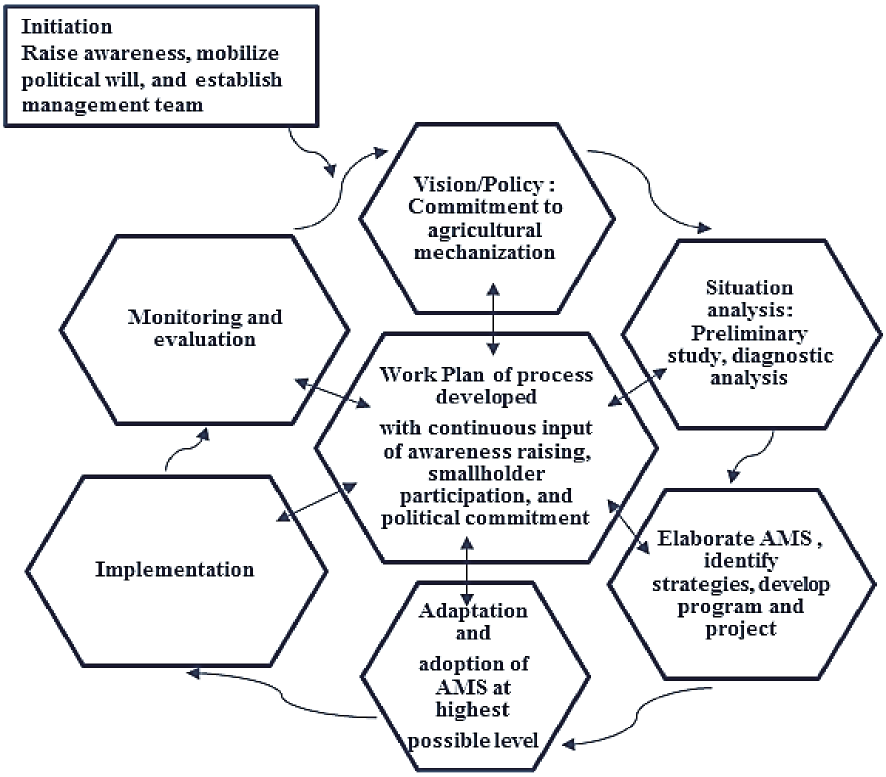


Figure 1.2: Framework for Agriculture Mechanization Strategy

Consequently, the development of a farm mechanization strategy requires an extensive knowledge in its widest terms of many sectors of agriculture. Farm management strategy is highly dependent on country specific social and economic conditions and the level of development of agriculture. The figure 1.2 represents the framework for the agriculture mechanization Strategy.

It further means that a simple collection of policies and procedures cannot determine an agricultural mechanization strategy. Every state should adapt to its needs and develop its own strategic plan for achieving the required level of automation. Thus, network agencies should be established and tasks to be carried out in state. Figure 1.3 depicts Activities and Corporations Network for Agricultural Mechanization. In fig

1.3, mechanization includes all levels of agricultural and processing technology, from simple and basic hand tools to more advanced and mechanized machinery. It eases and minimizes hard work, relieves manpower shortages, increases productivity and timeliness of agricultural operations, promotes the effective use of resources, boosts market access and helps to mitigate climate related dangers. Sustainable automation incorporates technical, economic, social, environmental and cultural elements while contributing to the sustainable growth of the food and agriculture industry.

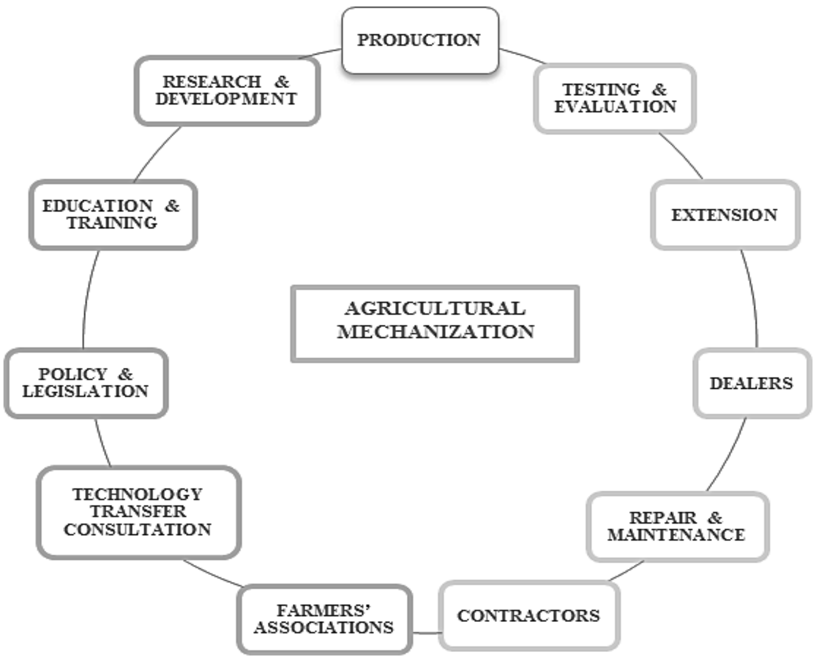


Figure 1.3: Activities and Corporations Network for Agricultural Mechanization

1.5 MECHANISED AGRICULTURE:-AGRICULTURE 4.0

This new philosophy centered on agriculture data has been expressed with several names namely: agriculture 4.0; digital farming or smart farming. Using mechanical farm technology to mechanize agricultural operations, a significant increase in the agriculture productivity can be achieved. Nowadays, with the advancement of technology, labour intensive agriculture practices are replaced with technology driven operations. The use of animals (oxen, horses, mules etc.) for agriculture operations has become a thing of the past. Even old tools like hoe and plough are fast losing their relevance. The Industrial Revolution introduces the use of tools and equipment in agriculture operations. The current mechanized agriculture practices include: tractors, trucks, and excavators, innumerable varieties of agricultural tools, drones, airplanes, and helicopters (for aerial application). The combination of satellite images and GPS increases yields even more precisely. It is a fact that mechanization is a significant contributor to urbanization and industrial economy. Also, mechanization fosters large-scale production, and in certain cases, may increase the quality of agricultural output. Mechanization may be partial or complete. The two major kinds of automation/ mechanization in agriculture are: mobile and static. The former strives to replace animal power on which agriculture has been built for many years; while the later works to reduce the amount of manual labor that is needed in specific processes [20]. Mechanized farming has gained ground in robust economies and equipment and tools are extensively put into operation there for agriculture related practices. But, inadequate farm economics make limited utilization of farming equipment. In India, the use of mechanized farming has not yet gained much traction for two key reasons: lack of knowledge about equipment used in farm operations and poor economy to sustain mechanized farming. This has impacted agricultural production.

Mechanization is focused on tillage and fertile soil preparations and reaping. More over 50% of the harvested crops in the world are harvested by machines. The remaining is done manually [21, 39]. However, cultivators and disc ploughs are still in practice and they offer several advantages. Sharing and renting of agriculture tools and equipment can put farming in the mechanized mode besides boosting productivity and net profit of the farmers.

1.6 AGRICULTURE 5.0 ROBOTICS AND ARTIFICIAL INTELLIGENCE IN AGRICULTURE

Signals provide farmers with important, trustworthy, and relevant data that helps them maximize agricultural output and reduce production costs. This is particularly useful on large farms where several operations must be monitored and managed simultaneously. Farmers can accurately measure weather fluctuations, precipitation, fungus gnats by using artificial intelligence. Much of this info and its analysis enable precision agriculture success. To better profitability, many producers turn to using AI technologies to improve yields and quality. The use of robots, sensors, and predictive analytics is revolutionizing farming. Farmers are utilizing sensors and crop monitoring to obtain data. Such data and related components set the stage for AI in agriculture.

The fundamental purpose of agricultural robots is to automate routine field chores, thereby freeing farmers to concentrate on more vital activities. Several similar robots exist for various reasons, including sowing, reaping, crop rotations, replanting, chemical spraying, and more. The introduction of software and hardware components into the driver replacement of agricultural tractors enables greater efficiency and more accurate land cultivation. With time, the world of farming shifts towards mechanized farming using mobile and stationary robots. This is predicted to result in higher productivity and reduced manufacturing costs. Agriculture 5.0 is based on Precision Agriculture concepts and incorporates robotic management and automated predictive analytics technologies. Thus, Agriculture 5.0 presupposes the usage of robotics and certain types of artificial intelligence. By history, farms have required a large number of seasonal employees to harvest crops and maintain productivity [49]. Although there have been large-scale demographic shifts away from agricultural communities, farmers face the issues of manpower shortages today. One answer to this labor issue is agricultural robots with AI capabilities.

As the rate of adoption of robotics for agriculture grows, it presents exciting opportunities for Smart Framing. These technologies are still prohibitively expensive for the majority of farmers, and those having small farms face significant financial challenges. Still, the budget of technology drops with time, and in the future farm robots will be used to boost output [50]. Higher yields along with advances in robotics are contributing to the growth of the worldwide farming and crop manufacturing process, as stated in a confirmed Marketing Research study. Farming technology startups have raised over 850 million dollars in the previous five years.

1.7 SMART FARMING

Modern agriculture referred to known as "agricultural 4.0", is the next big thing. A concept now referred to as "smart farming" refers to farm management utilizing state-of-the-art technology such as precision equipment, the Internet of Things (IoT), sensors, controllers, location systems, Data Analytics, Unmanned Aerial Vehicles (UAVs, drones), and robots.

Intelligent farming employs current technologies in order to boost crop type and effectiveness. Intelligent devices include automated systems, information management, soil monitoring, and GPS navigation. Farming has benefited throughout the years because of the advancement of smart farming, which provides people with innovative technology and tools that help people produce better and more crops at a lower cost. Smart farming might prove to be a super technique for agriculture. The goal of intelligent farming is to help connect small and large-scale producers throughout the world. Agricultural innovation has been backed up by technological advancements, internet of things expansion, and the arrival of smartphones. Agricultural operations that were done in history have radically transformed [51]. This may be linked to technical advancements, such as the usage of machinery, gadgets, detectors, and systems engineering. Farmers now employ technologies like satellite photos, air temperature and humidity sensors, GPS technology, and robotics. Such technological advances have led to farming being both economical and ecologically growth.

Technologies related to intelligent farming may act as new mechanisms to encourage other well-known or rising agricultural models, such as family farming (small or complicated areas, distinctive cultures, and/or animals, preservation of high-quality or distinctive kinds) and organic farming. Farming can also assist with environmental issues such as water use and treatment and input optimization. The Internet of Things (IoT) provides a whole new viewpoint on agriculture since it tracks and monitors growth elements like irrigation and fertilizers [52].

1.7.1 Smart Farming Systems

By using remote sensing, the smart farming system saves money, boosts output, and enables better resource management. Constant crop-growing in distant areas demands more attention, soil, and water. Because they're linked to smart irrigation and management, which saves time and resources by doing things like testing the pH balance of the soil, analyzing temperature, and finding all the available time, farmers can concentrate on important matters like pest control, irrigation, and modifying soil conditions. This figure 1.4 shows the smart farming supply.

Remote data is vital for precision farming, along with computer and equipment mechanization that supports increasing issues and production assistance. In resource management, it is a market approach that balances buyers and sellers.

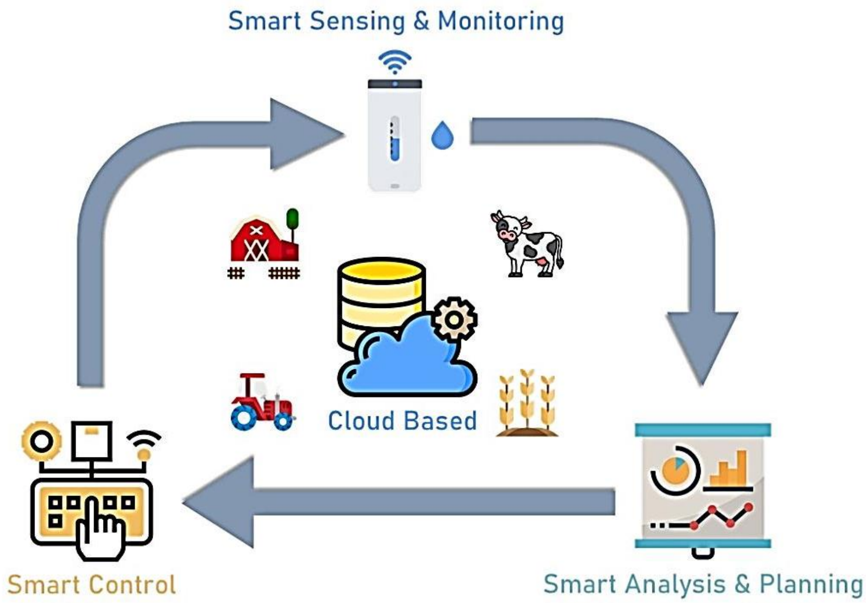


Figure 1.4: Smart Farming Supply

1.7.2 The Real Purpose of Smart Farming:

Public concern about food safety is on the rise, in part, due to a number of food crises. Clio metrics are used to follow, predict, and guide all stages of the growing and harvesting process for a crop. With the concept of smart farming the user can get the right equipment on right time for harvesting the crop to get better yield. In such systems, networks are more complicated. Many agricultural items are sold using a strategy of reducing costs, which results in low profitability. In this growth, Smart Data technologies play a key shared role: computers are fitted with all kinds of sensors that provide secure, machine-based data in their environment.

1.7.3 Artificial Intelligence and Robotics Implementation in Agriculture

Crop pests, insect infestations, water shortages, weeds, and other issues face the agriculture industry. Due to current agricultural practices, these issues result in significant crop loss, economic loss, and extreme environmental hazards. AI and robotics technologies have the ability to effectively solve these problems. The study includes important contributions that use AI and robotic techniques to solve the challenges that agriculture faces [53]. The importance of key milestones in the development process, as well as the challenges of widespread adoption of these technologies, as well as their social, economic, and environmental implications, are examined, with a focus on how to address adoption challenges.

1.7.4 The Lifecycle of Agriculture

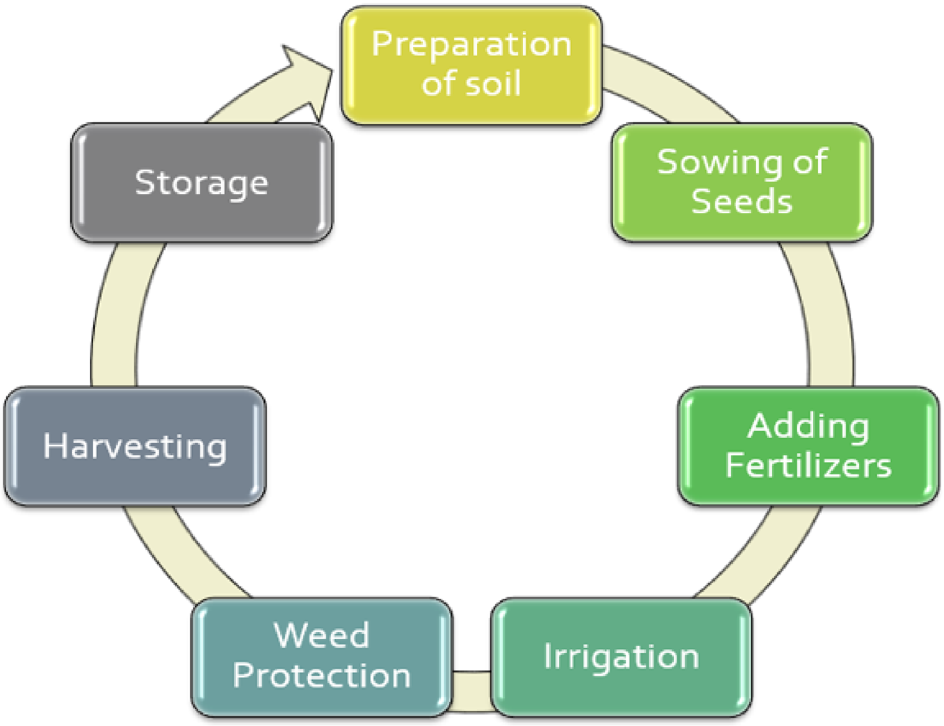


Figure 1.5: Life Cycle of Agriculture

Various factors include precipitation, climate, and humid affects the lifespan of agriculture. Climate change is caused by deforestation and emissions, which prevent farmers from preparing the soil, planting crops, and harvesting. Figure 1.5 depicts the life cycle of agriculture.

Crop needs a certain sort of soil nutrients. Three major nutrients needed are nitrogen (N), phosphorus (P), and potassium (K). Inadequate nutrient supply may harm crops. Weed control is vital in agriculture. Under uncontrolled conditions, inflation might rise, and fertilizer consumption might occur [54].

In agriculture, artificial intelligence and robots improve crop yield while boosting real-time management, harvesting, manufacturing and marketing. Various high-tech computer-based systems are being developed for plant disease identification, weed identification, and yield prediction, as well as crop growth monitoring. AI and robotics methods help collect information about each circumstance and provide the best answer to an issue. AI and robotics-based breakthroughs have the capacity to tackle these difficulties swiftly. These technologies can enhance agricultural efficiency, irrigation efficiency (using less water), soil management and crop quality. Using AI and robotics-based technologies, farmers can generate more and better yields while cutting production costs and improving revenues.

1.7.5 Why Does Agriculture Consider Artificial Intelligence And Robotics?

Environmental advantages or a 30% boost in agricultural yields are possible with AI-enabled technologies. Because of new technology and innovation, the agriculture industry was forced to adapt the concept of artificial intelligence. Artificial intelligence and robots are pushing our present agricultural methods to increase yield and reduce waste while reducing environmental impact.

1.7.6 Applications of AI and Robotics in Agriculture

Equipment sharing and renting is a real solution for farmers, since this might lead to a significant increase in profits. Obtaining early access to the equipment necessitates a significant amount of knowledge and expertise, and prediction is done on the basis of various parameters entered into the system. The Machine Learning algorithm models have made it reasonably straightforward and rapid to promote renting and sharing.

1.8 CONCEPT OF MACHINE LEARNING

ML is an analytical model building that automates data analysis. This is the method of data analysis that automates analytical model building. It is the study of computer algorithms that can be improved by the use of data. This type of algorithm builds a model based on training data. ML has wide variety of applications such as traffic alerts, social media, self-driving cars, Google translate and many more where it is not easy to develop complex algorithms to perform the selected tasks. All the classification of machine learning is not statistical learning but it is a subset closely related to computational statistics. In business related issues, Machine Learning is concerned with the predictive analysis.

The aim of this briefing is to provide an overview of machine learning techniques that are currently being used or considered by methodological departments across the country. In today's world, a vast amount of information is readily available. As a consequence, it is important to evaluate such data in order to extract some valuable information and to build an algorithm based on this research [55]. Machine learning is an application of artificial intelligence that is used to create algorithms based on data patterns and historical data relationships. Although Machine Learning is based on the principle of automation, it still needs human supervision. In order to get a framework that performs well on yet unseen data instances, Machine Learning needs a high degree of broad generalization [56].

Machine learning is a relatively modern computing platform that encompasses a variety of data processing methods. Most statistical techniques are predicated on the idea of determining the exact probabilistic model that properly explains observed data within a group of similar models, and most machine learning techniques are based on finding models that best match data. As a result, machine learning techniques have an advantage over statistical techniques in that the latter do not include underlying probabilistic models, while the former do. Despite the fact that some machine learning techniques employ probabilistic models, traditional statistical techniques are often too strict for the coming Big Data age, as data sources become increasingly dynamic [57]. Figure 1.6 shows how the trained data is input into the Model to make the predictions.

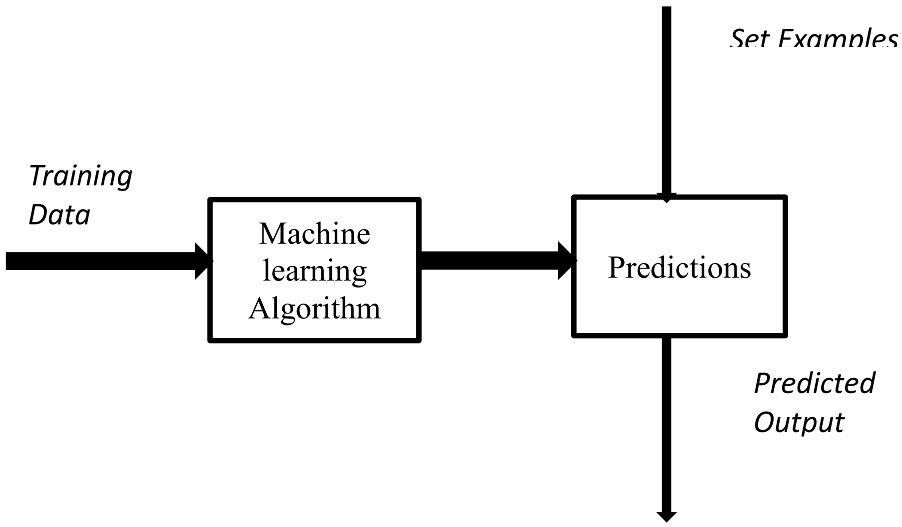


Figure 1.6: Working of ML Model

ML is a computer knowledge from which the provided data can perform various task. In order to solve the real time scenario or applied research problems at hand and to execute all the required steps, it is easy to program an algorithm telling the machines. For the more advanced tasks, it becomes a challenge for humans to create the algorithm manually. In actual practice, it becomes an effective platform to create own algorithms with the help of machine rather than program with expected specifications.

1.8.1 Learning Tasks

Supervised, unsupervised learning and dimensionality reduction are the three main categories of ML. In the former case data is presented with inputs and outputs. In some cases, partially available inputs are present. In order to predict the missing output for the test data a training model is used. To execute both the heads of supervised and unsupervised learning types the dimensionality reduction is reduced. From the original data, data set can preserve as much information as possible. This will help to provide the most compact dataset to preserve as much information as possible from the original data.

1.8.2 Machine Learning Techniques

There are some models that have been implemented in this present work

- Regression
- Clustering
- Instance based model
- Decision Trees

A) Regression

This concept comes from supervised machine learning, which can help us to predict and explain object based on a categorical data. For example we can predict equipment prices based on the attributes such as type of equipment, location and the demanding days. Figure 1.7 represents the basic regression plot.

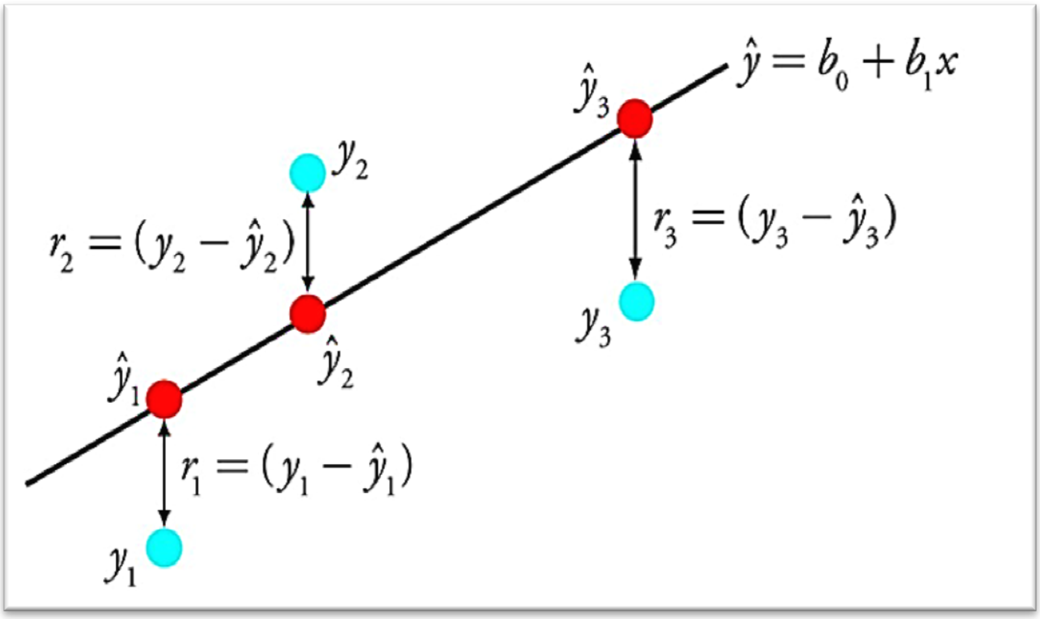


Figure 1.7: Regression Plot

Figure 1.7 depicts regression plot where $\widehat{y1}$, $\widehat{y2}$ and $\widehat{y3}$ are the predicted values on a regression line and y1, y2 y3 are actual values. Here in this graph r1 r2 and r3 are called residuals value on vertical axis and explain the difference between actual and predicted value on vertical axis. This regression analysis can perform with various effective algorithm such as simple linear regression, multiple linear regression, polymer linear regression, decision tree and support vector machine.

B) Clustering

It is an unsupervised learning technique. This technique doesn't have any output information for the training process. Clusters can organize a bunch of data based on the different clusters. Clustering start with data point and these data points can be measured like length and width. Clustering is used to create group of data which is called clusters. The clustering happens fully automatically.

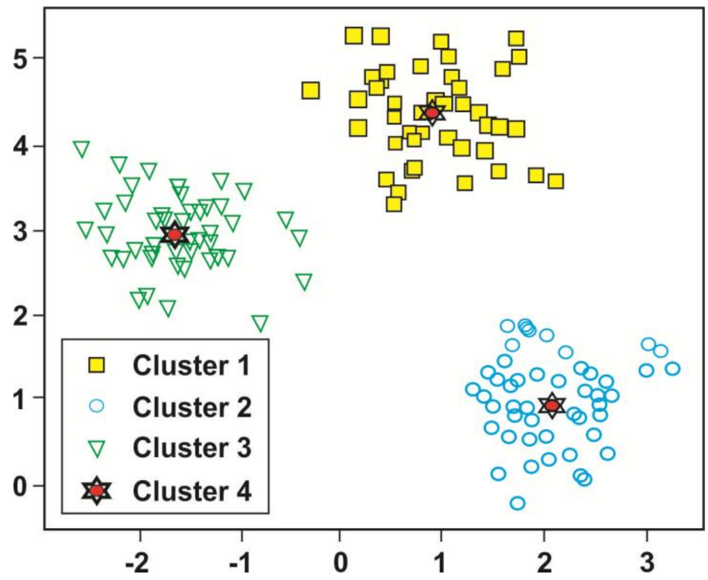


Figure 1.8: Clusters in Scattered Plot

Clustering is the process of separating a population or set of data sets into a number of groups such that data points belonging to the same group are more identical to one another and different to datasets belonging to other groups. It is essentially a collection of items based on their similarity and dissimilarity. This figure 1.8 demonstrates that the system has a large number of data set in the form of clusters. Content-based clusters will be formed automatically using our technology. For instance, in the scenario of renting and sharing agricultural equipment, our system would get the user's current position from the whole India map. In the current study, we've implemented Google API, which identifies the location of the equipment to be hired. Clustering is critical as it implies the fundamental classification among data sets. Clustering is totally subjective. It depends on the consumer, what criterion satisfies their requirements. An example of this would be: We may be interested in identifying representatives for homogenous groups (data reduction), as well as discovering "natural clusters" and describing their previously unknown attributes. This method makes hypotheses which will provide clusters of points with varying validity.

C) Decision Trees

Decision tree is one of the best modeling techniques used in machine learning. It is one of the predictive modeling approaches used in machine learning w here the data is continuously split according to the particular parameters; namely -decision nodes and leaves. These are the basic fundamental steps to explain this tree. The leaves represent the final outcomes, and the decision nodes represent the points at which the data is split. Training data may be used for both regression tasks, but is mostly employed for addressing classification issues. Figure 1.9 depicts representation of decision tree. An internal node represents a dataset feature, a branch represents a rule base, and each leaf node represents a result. A decision tree has two nodes, a decision node and a leaf node. Selection nodes serve to make any decision, while leaf nodes act as the results of such choices. The judgments of the tests are based primarily mostly on the dataset's characteristics [58].

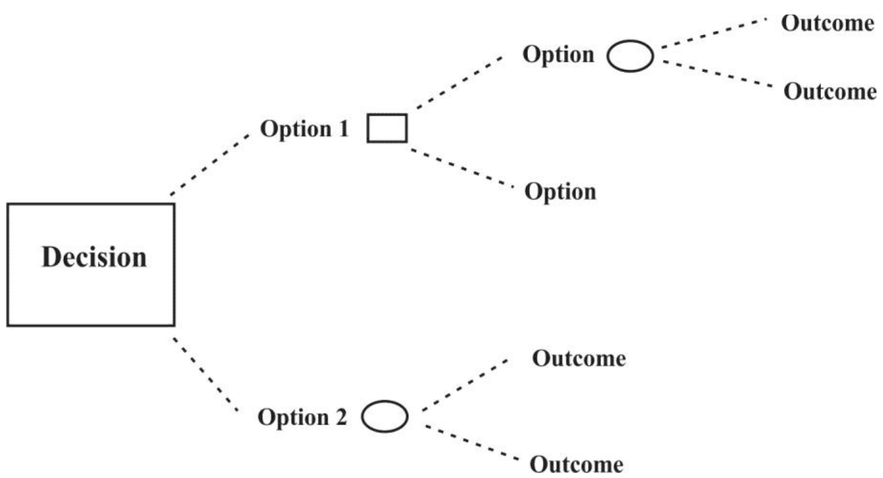


Figure 1.9: Representation of Decision Tree

D) Instance based Model

Instance-based means building hypotheses directly from training samples. It is a memory based model that can compare trained instance with the new problem instance. The one of the most important advantages of this based model on the others methods, the unseen data can be easily adapted by this model I.e. it is a memory based model it may simply store the new instance. This model is exactly linked with the renting and sharing of the equipment i.e. how this system can get the information about the number of equipment's used by the user in last years.

E) Artificial Neural Network

Artificial neural networks are machine learning algorithms that simulate human brain. As stated above, the neurons in our nervous system can learn from history, in the same way the ANN is capable of learning from the data to produce forecasts or categories. ANNs are time - varying mathematical methods that discover a new sequence in complex relationships between outputs and inputs. Neural network networks are commonly used in tasks like machine vision, voice recognition, text mining, and diagnosis. Because ANNs learn from illustration data sets, they have a major advantage. Most commonly, the ANN is discrete structure estimation. With these tools, it is possible to arrive at distribution solutions at a cost effective rate. ANN is also capable of taking a dataset and returning the final output. ANNs can improve current statistical tools due to their advanced meaningful insights.

1.9. RECOMMENDATION SYSTEM FOR RENTING AND SHARING

A suggested system is used to provide the best possible alternative to a user looking for a certain product on a system. In this research, farmers interested in renting equipment will use the search module to locate the appropriate equipment. The farmers will provide the system with parameters and depending on the search, the system will propose something to the user. The proposed system includes many options.

1.9.1 Collaborative Filtering

Collaborative filtering is widely used in the building of recommender systems. Collaborative filtering assumes individuals who previously agreed would agree in the future, and that they would enjoy products similar to those they liked in the past. The suggestions are generated using solely information about user/item rating profiles. To find peer users/items with a comparable rating history, the system uses this neighborhood. CPL approaches are referred to be memory-based and model-based [59]. Many optimization devices have been used in recommender system evaluations. Explicit and implicit modes of data gathering are used to develop models from user activity.

The following are some examples of explicit data collection:

- Inquiring about a user's rating of an item using a sliding scale.
- Inviting the user to do a search.
- When making a collection of goods and asking users to rate them from favorite to least liked.
- If you provide two options to a user and ask them to select the better of the two, this is called the two- alternative paradigm.
- Asking people to make a list of things they enjoy

1.9.2 Content-based Filtering

Another method to recommender design is content-based filtering. Content-based filtering algorithms are based on an item description and a user profile. Known data, but not user data, is best served by these strategies. Content-based recommenders see suggestion as a classification issue and build classifiers for each user based on an item's characteristics.

A user profile is used to describe the goods the user enjoys. These algorithms search for things that are comparable to the ones that a user has previously enjoyed or is now analyzing. It doesn't need a user sign-in to build a temporary profile [60]. Candidate products are compared with previously rated products and the best-matching things are suggested.

1.10 DEMAND SUPPLY ALGORITHM

Price in a market is determined by supply and demand. This assumes that, in a competitive market, the price of any product will fluctuate until it settles at a position where the amount of that product requested equals the amount of that product provided, resulting in an economic equilibrium in which prices and quantities exchanged are equal. A model is a theoretical construct which expresses business development using a set of variables and a set of interactions among them. The economic framework is a basic model meant to depict complicated processes. Structural parameters are often made economic models [61]. Setting the price at which a firm will offer its goods and services is part of the firm's marketing strategy. When determining pricing, businesses consider the price at which they might obtain the items, production cost, competition, market state, brand, and product quality.

Innovation is one of the four Ps of the marketing mix, along with promotion, product, and place. The single income generator of the four Ps is the price. Other Ps of marketing, like price elasticity, will contribute to causing price hikes to boost revenue and profits. This is a method of setting pricing on buy and sales orders that relies on several elements, such as: a fixed price, per-unit quantity break, campaign promotion, special vendor quotation, entry price, shipping date. Pricing mistakes may be prevented if automated pricing mechanisms are in place. You can only create demand for a product if the buyer is willing and able to purchase it. So, the Invested money is critical in marketing [62]. It is employed as a tactical choice in reaction to changing competitive, market, and organizational conditions. A company's pricing strategy reflects its company goal and principles. Typically, the company's long-term strategic plan includes this price approach. The strategy aims to give a clear price setting approach that is compatible with other aspects of the marketing plan. As a general rule, prices will fluctuate, but the business model will always be consistent throughout the planning term, which is normally 3–5 years, but in certain sectors may be a longer time of 7–10 years [63]. A long-term pricing plan was set while keeping a flexible price point in mind.

1.11 SUMMARY

This chapter covers all the aspects of agricultural mechanization in India and the root causes of farmer suicide. Several factors explain why farmers commit suicide in India, including flooding, famine and indebtedness. Mechanization introduces accuracy and timeliness into agricultural activities, higher field covering over a short time, expense, resource consumption, and conservation of moisture content under stressful conditions. We addressed the necessity for leasing and sharing agricultural equipment. Renting and sharing is a potential key that enables farmers to borrow equipment at a reasonable cost rather than purchasing the gear. It also allows the agriculturist to be more adaptable in cultivating activities and aids in various crop cycles. Custom hiring is a novel concept in farming that intends to stimulate improved resource management tactics among farmers that use comparable farming practices. These resource-sharing techniques at a cheaper cost to individual farmers are prevalent in specific sections of the country regarding agricultural equipment and tools. Additionally, we have addressed machine learning and a recommendation system based on content and collaborative filtering. Furthermore, we have gone through the demand and supply algorithm that applies inverse price-demand relations. In the second chapter we have done a literature survey from which we came up with several ideas, and discovered a need for equipment Renting and sharing. The methodology described in the third chapter is how we applied the ideas mentioned above. Results and discussions are discussed in the fourth chapter.

Chapter – 2

LITERATURE REVIEW

This chapter examines the concept of Indian farming. Farm production is decreasing every day. Of the several contributing reasons that lead to low productivity and yield, one is the non –availability of the appropriate equipment to the farmers to carry out various agriculture operations well in time. Low productivity grips the farmers in a vicious cycle of debt trap, which finally pushes them to suicide. This literature that deeply studies the various problems faced by the farming community concludes that a decision support system is required for renting and sharing of equipment to tide over the crisis. The study also identifies that a contact with the custom hiring services and innovative resource renting and hiring framework development, is essential in influencing technology adoption.

2.1 MECHANIZATION'S IMPACT IN AGRIBUSINESS EMERGING MARKETS

The exponential population growth has strained agriculture. The agriculture land size is decreasing, but the demand to feed more and more mouths is increasing day by day. Natural and man–made factors have further hit the food productivity. Therefore, mechanization is a panacea to most of the ills that afflict agriculture. Herein, the role of machines to carry out agriculture operations to maximize efficiency and yield comes into play. Without the optimal use of machines, agriculture production cannot be hiked. The developing countries lag behind in farm productivity owing to improper use of machines in various agriculture operations. On the other hand, automation of farming operations contributes significantly to rural and agricultural growth in many developing countries. Therefore, farmers must be encouraged to use machines in the field to increase efficiency and the produce of their products. It is also necessary to put agriculture on automation the current rate of agricultural production required to feed world population cannot be realized without mechanization [39]. Unfortunately, the use of farm machinery, unfortunately, is still under consideration in most parts of the world, including in some parts of India. It is high time that both the government and the private sectors should put their head together to push the country towards mechanized farming.

Researchers are developing strategies to introduce the innovative system of mechanized farming to boost productivity and economy. Many farmers in Punjab, Haryana, and western Uttar Pradesh have already been benefitted from tractors, harvesters, sprayers, planters, drills, power drills, riggers, and single axle multifunctional machines. Mechanized farming has boosted their productivity besides strengthening the economy of their respective states.

2.1.1 Potential Impact of Machinery Performance and Selection

The researchers conclude that crisis that beset agriculture sector can be addressed by mechanization of farming operations. The present study identifies a host of factors that force farmers to take the extreme step of taking their lives. The factors that push farmers to commit suicide are: low productivity, high input cost, low prices of crops fixed by government, rising costs of pesticides, inadequate irrigation, loss of biodiversity, distress sale of crops, debt, lack of resources to introduce modern techniques in their agriculture operations et al. Many socio, economic and natural factors also compel the farmers to put an end to their lives. However, those who commit suicide because of unseasonal rains are mainly small and marginal agrarian workers [64-66]. With no alternative source of income except farming, marginal farmers primarily depend on financing to carry out various agriculture operations, ranging from raising necessary farm infrastructure to taking the yield to mandis. If the crop fails, then debt mounts. And, in this scenario, a small and a marginal farmer take recourse to suicide. Many small and marginal farmers have ended their lives by consuming a poisonous substance or hanging from a tree of their farms. Suicide of farmers is a pan India phenomenon, but it is more conspicuous in Punjab. As per a report, more than one lakh farmers (small and marginal) commit suicide in India every year.

The situation is grim in Punjab also. Approximately 4687 farmers and farm laborers committed suicide in Punjab between 2001 and 2010 die from indebtedness [67]. Several types of research have supported the notion that it is the debt trap that forces the farmers to commit suicide. Drastic increase in the rising in prices of raw materials like fertilizers, pesticides and diesel, et al also push the farmers to the jaws of death. In this recent study, the authors are concentrating on designing a sound decision support system. Through this system users who wish to lease their equipment can do it easily. This system will also help the farmers to get access to correct assets simply by getting themselves logged in to the framework. This is how a farmer can hire tools for carrying out his agriculture operations. Thus, this framework will enhance the financial support of the farmers. Further, resource sharing shall play a significant role in decreasing the input cost besides boosting Punjab's agriculture economy.

2.2 MECHANIZATION IN AGRICULTURE

Mechanization in the agricultural sector has been defined in several ways. It refers to the use of tools, implements and powered machinery in the farming operations. Agricultural mechanization requires power to conduct farm tasks. There are three main energy sources in agricultural mechanization: human power, draught animal power, and mechanical power.

Human power is the earliest and most basic level of agricultural mechanization . It uses human muscle to operate hand tools and simple implements. In contrast, animal power utilizes draught animal muscle in operating implements and machines to perform farm tasks. Mechanical power, however, is the highest level of power and it driven and aided by technology. It does not rely on muscle power. Agricultural energy sources other than muscular power needed for various farm operations, mobile or stationary processes, are: wind power, solar energy, water power, electric power, internal combustion engines et al. The application of these sources varies across countries and depends on local circumstances, especially on their availability.

The field of agricultural mechanization is very vast and it covers the use of farm equipment and the techniques associated with its use. Agricultural mechanization also covers the process of supplying mechanization inputs to farmers in an efficient and effective manner, which, in turn, includes the material input of industrialization (manufacturing and or importation), distribution of farm machinery, repair and maintenance services (including spare parts), institutional support, management, and utilization of agricultural tools, implements et al [48]. Meanwhile, farmers mechanization in agricultural production operations includes: agricultural land development, crop production, harvesting, and preparation for storage, on-farm processing et al.

2.3 THE ROLE OF AGRICULTURAL MECHANIZATION

2.3.1 Mechanization to Increase Farm Labor Productivity

Automation in agriculture entails using multiple power sources, farm tools and equipment to minimize human and animal drudgery. Farm mechanization's ultimate goal is to increase total efficiency and output while lowering production costs. For mechanization’s effect on agricultural productivity and development, farm mechanization is a must. It is a prerequisite for reducing human drudgery and increasing agricultural productivity. Different levels of mechanization have been achieved in India depending on the use of other inputs such as irrigation, high-yielding seed varieties, chemical fertilizers, herbicides, pesticides et al [22].

There is a catch here. Mechanization cannot resolve the issue of productivity in India. Mechanization farming can render a lot of farm workforce unemployed. The effect of farm mechanization on labour employment has already been a source of concern and debate. According to the facts, mechanization helps generate employment. However, it depends on the size of the farm, the types of crops cultivated, and the type of labour employed (casual agricultural laborers vs. permanent farm servants).

However, automation in agriculture generates chiefly indirect employment. Trained and unskilled labour is always needed to repair, maintain and use the equipment. Automation or mechanized agriculture boosts productivity by cutting input costs significantly besides carrying out farm operations with speed on a large track of land. With the use of agricultural machinery, the time spent on farming gets decreased by around 60% to 97%. Mechanized farming also gives a fillip to the manufacturing sectors, such as machine and accessory part segments, to grow dramatically.

2.4 OVERVIEW OF FARM MACHINERY HIRE SERVICES

In many developing countries, ownership of farm machinery is minimal because of the small-sized farms owned by most farmers. Additionally, the renting and sharing of equipment for farmers in developing areas is mainly determined by its monetary feasibility. Furthermore, it requires investment. This fact often leads to the collective use of farm machinery by farmers or individuals in groups or organizational forms. These organizational forms are classified into public and private sector categories. In developing counties, farm machinery ownership conditions exist as under:

1. Public hire service
2. Private hire service
3. Private owner-user with Hire service for excess capacity
4. Exclusive private owner-user
5. Cooperative ownership
6. Informal joint ownership

2.4.1 Definition and Types of Machinery Hiring Services

Hire services (rental, custom, or leasing services) in agriculture are an activity of a machinery service provider in delivering services to farmers. It includes land preparation, planting, spraying, threshing, or transportation et al. In addition, hire services may include draught animals as the source of power to deliver services to farmers. Agricultural machinery services are popular in developing counties as most farmers are small landholders there and they are unable to expand and increase the production of crops due to the lack of availability of equipment. Hire services are an affordable and cost-effective means for farmers to obtain farm machinery and equipment. Through machinery hiring, small and marginal farmers can utilize farm machinery without owning it .

There are two ownership types in the business of farmer hire services. The first category is farmer contractors (individual ownership), where an individual farmer provides commercial machinery services to other farmers. The second type is farmer group machinery hire providers (group ownership), where farmer groups provide commercial machinery hire services to their members by pooling their resources and purchasing the required machinery or obtaining the machinery from a government mechanization program. As opposed to individual ownership, it is argued that group ownership will often have easier access to government programs, such as access to credit. However, there are problems associated with group ownership. The first issue is the timeliness of service because all members will probably require machinery services simultaneously. Managing and operating the machinery by a skilled person is another major issue that troubles farmers. It is argued that the farmer group ownership model works in situations where all the members have mutual respect and confidence in using the machinery hire services unit.

2.4.2 Public-led Machinery Hire Services

As the various government-led scheme of hiring tools and equipment are not viable and sustainable , many countries in Africa abandoned this scheme between 1980s and 1990s [68]. It thus becomes clear that without the aid and support of the government, the project cannot take off. Therefore farmer to farmer hire services have existed as part of the government policy in many developing countries through subsidized mechanization programs. However, the program of funded machinery hire services is reported to be unsustainable in some developing countries. A review of the government intervention programs was conducted in promoting agricultural machinery through state-led agricultural machinery services in Asia and Africa. Some studies have reported several unsustainable mechanization programs in developing countries; mainly hire services schemes [68]. This program has failed because of location or geography. As the location being relatively far from the hire service providers, cost of hire operating services increases manifold. Secondly, the state-led farm service units could not operate efficiently because the service charges were very high. Rigid and inefficient public administration (bureaucratic issue) undercutting private hire machinery providers were the other issues that beset the program.

The evidence of efforts of the previous governments in delivering agricultural mechanization intervention is also found in abundance in research studies conducted recently. Researchers argue that program to provide farm machinery services in some developing countries failed to serve the famers in terms of timely and profitable mechanization services. With the role of the private sector being undermined, the program turns out to be unsustainable. For instance, in Kenya and Brazil, public machinery hire services were not profitable because service charges were set cheaper than the service provided by the private sector. Meanwhile, in Punjab, the benefit of the government-led farm hire machinery units was not timely and adequate, resulting in delays in sowing crops [69].

Likewise, in Abuja, Nigeria, farmers have low access to farm machinery hire services. This may be due to bureaucratic issues. Tractors were not distributed to agencies that serve farmers with machinery services. This points to the weakness of the public sector in fostering the use of the tractor by farmers. Similar to the other states, it was explored that in Ghana, a state-led automation program, the Agricultural Mechanization Service Enterprise Centers (AMSEC) could not make profits because of the underutilization of tractor-hire services. AMSECs mainly offered tilling services locally and rarely served farmers by migrating to different areas [70].

The pattern of agricultural mechanization policies was observed and found to be poor in performance. This context examined the implications of government intervention by examining the adoption patterns and economic impacts of automation. The authors argue that in promoting tractor-hire operations, the public sector tends to believe it is a way to achieving agricultural modernization. Meanwhile, the introduction of tractors to farmers would not directly influence the farmer's decisions in using this piece of technology, which, in turn, would not lead to intensification of agri based operations [70].

As argued, mechanization is similar to other agricultural inputs. It is akin to providing seeds and fertilizers to the farmers. Thus in reality, it is a part of the management tool and it is executed to maximize production and profit. The system has not yielded desired results for the public sector does not shape the intervention system into a more autonomous design. While the private sector provides services like supplying equipment, spare parts or maintenance services carries out its operation successfully. As the many government interventions have poor longevity, the public- led hire service provider system collapses, making the government withdraw itself from the program.

2.4.3 Private-led Machinery Hire Services

Even though most public-led machinery hire service programs are not sustainable, there is growing evidence that government initiatives have led farm mechanization to spread in rural areas over the past years, particularly in Asia, Africa and Latin America. For instance, in Zambia, the number of commercial farmers increased 38 percent between 1970 and 1988. In addition to it, the number of farmers subsistence fell by an average of 0.5 percent per annum in the same period due to the subsidized mechanization program by the Zambia Government [71].

Meanwhile, a study identified the transformation of farm machinery over the past 50 years. This transformation is attributed to the subsidized mechanization policy in the post Asian Green Revolution era [72]. The authors argue that small-scale machinery has increased the intensity of farmers in using various rural and agricultural resources. This is indicated by increasing yields and cropping intensities, careful use of fertilizer and water management, and by the growing use of agricultural post-harvest processing equipment. Since 2003, the private sector started to lead the machinery hire services in parallel with the AMSEC subsidized program in Ghana [73]. This is different from South Asia, where medium and large-scale farmers are the leading players in the machine hire business. The case of Ghana is different because here the government hire services could not meet the market demand for hire services.

Many scholars have argued that one of the triggers of private-led mechanization uptake, particularly in hiring agricultural machinery is a facilitating mechanization policy that attracts and supports the private sector to conduct business in farm machinery services. For instance, it was identified that the government of Bangladesh in the 1990s altered the import policy on agricultural machinery, allowing small Chinese power tillers to enter the Bangladesh market. The shift to mechanization policy in Bangladesh was necessitated by a significant decline of draught oxen population, which got reduced due to natural calamities (floods and cyclones) that struck Bangladesh in the late 1980s [74]. As a result, the private sector pitched in quickly and edged out the public sector in the import of farm machinery by importing less expensive equipment from China.

With the increase of agricultural machinery population in the Bangladesh market, 72% of farmers used farm machinery, particularly power tillers. The remaining farmers stuck to the traditional mode (draught animals) for land preparation. As most farmers in Bangladesh use power tillers, it indicates that the market for machine services flourishes [75]. In Ghana private sector got benefited from the import tariff exemption imposed on all farm machinery imports when government of Ghana executed the policy to import equipment to supplied to AMSECs. As a consequence of this import policy, the private sector has been able to import affordable second-hand tractors over the past ten years and become the country's main providers of machinery hire services.

To create a facilitation policy and also to foster mechanization in developing countries, many scholars suggest that the role of the public sector should be adjusted to allow the private sector to build their market in the machine hire business. For instance, the public sector should promote the demand for farm machinery and the provision of spare parts. The public sector should facilitate the private sector in acquiring and maintaining farm machinery by reducing transaction costs, The import policy as evidenced in the case of Bangladesh and Ghana is a copybook example.

It was suggested that the government should consider how much mechanization should be introduced to foster the demand for agricultural machinery. However, materializing this policy poses a challenge for the government. For instance, it was argued that in developing countries, where the majority of agricultural policy is dedicated to supporting farmers through subsidies, adjusting/restructuring policy is a challenge. In such a scenario, the farmers and rural entrepreneurs might delay buying new farm machinery even though they realize that business in hiring machinery is profitable.

2.4.4 Factors Shaping the Operation of Farm Machinery Hire Services

The operation of machinery service providers (public or private providers with individual or group ownership), is affected by the local circumstances. Robotic technology is sensitive to agro-climatic factors and economic factors. Different environmental or economic conditions will affect the utilization of technology. Many studies have found various factors shaping the operation of farm machinery hire services in developing countries which include: seasonal demand for machinery services, the performance of managers of machinery service providers, the availability of skilled operators, the availability of financial resources, the supply of agricultural machinery services, access to training, access to repair, and maintenance networks (including spare parts) and rural infrastructure et al .

In some studies, some factors were found to be significant in contributing and shaping the operation of machinery service providers. Socio-economic status of farmers is one of the most important factors which influence the farmers to operate power tiller operated seeders (PTOS) as a profitable business in Bangladesh [75].

However, some factors are linked to other factors. The demand for tractor services was also influenced by the topography of the land, cropping pattern and diversified crop production. In Riau Province, it was revealed that the demand for machinery services tended to be seasonal. Hence, it was influenced by seasonal work.

In this research, the factors contributing to shaping the operation of machinery hire services are categorized into three main categories: 1) the role of skilled staff in supporting the business, 2) demand for machinery hire services, and 3) institutional support. The categorization is based on the themes that emerged in the results, which were considered important in this research. These factors fit into these categories. In the next section, these factors are reviewed.

The role of skilled staff in supporting the business

a) A Manager of a Machinery Service Provider.

It is argued that a competent manager of a machinery service provider is an essential factor in influencing the direction and the performance of the machinery hire business. A manager of a multi-farm should have sound knowledge of business management and must know how to use the same farm power, machinery, and equipment in more than one farm unit". The manager should also have knowledge about record-keeping, functional accountancy, personnel management, government regulations, procurement, and marketing. A manager should also possess technical knowhow and relevant expertise for the operation, management, and repair of farm machinery besides having a sound understanding of agriculture.

Due to the organizational structure of the machinery services managed by farmer groups, particularly in the Republic of Indonesia, which positions the manager as the leader of the machinery service group, the manager's role becomes essential. Studies in have revealed that critical skins of a manager, such as good record-keeping and managerial skills, determine the success of the IRSAMs. Furthermore, according to a survey of small-scale farm machinery service providers in Riau Province, a manager has a key role in determining the service charge [76]. The authors emphasized that the manager's honesty and the other members of the business in conducting their roles are essential to the group's development.

Additionally, it is argued that a manager should possess marketing skills. To help the business flourish the manager needs to introduce and promote mechanization at the farm level. Meanwhile, a manager's performance in leading the business is arguably related to the role of the government in empowering farmer groups that are operating machinery hire services. A study in Central Sulawesi Province found that managers in the surveyed areas tended to be unprofessional in managing the groups [77]. The authors argued that lack of empowerment and monitoring from the government, particularly in the management aspects, was one of the causes of this problem.

b) Farm Machinery Operators

There is common agreement that farm machinery operators of hire service providers have essential roles in influencing the group's operation. Farm machinery operators perform field operations of a hire service provider. Scholars agreed that sufficient technical skills sound knowledge, and experience of agricultural machinery operation is required for operators to perform machinery services.

By mastering farm machinery operation for hire services, the operators will gain skills and knowledge, which will financially benefit the group as they are recognized by other farmers and will help the hire service providers capture a larger market share. Through technical training, the operators' skills, knowledge can be improved. For instance, two entrepreneurs have successfully created and developed a hire service business after participating in FAO technical and business training in 2008 [78]. In contrast, it is found that insufficient skills of operators in handling farm machinery influenced the seasonal workload of machinery service. In turn_ it affected the business operation.

The operation of machinery hire services is also affected by the availability of skilled operators. A study in Riau Province found that machinery providers could not identify machinery operators due to a minimal number of capable operators, especially during the paddy growing season. As a result, the owners increased the hourly rate fee of the operators to find them in time. Similarly, in the Special Region of Yogyakarta, operators received a more significant portion of the total variable cost (fuel. oil. and operators) because this is the strategy of the managers to keep the operators in the business and to encourage them to maintain the quality of work [79].

About the increase of operator wages, a study in Ghana found that due to the characteristics of incentives received by operators of the AMSEC model, they tended not to take good care of farm machinery. The authors stated that to deliver services to farmers, the owner of AMSEC hires operators and the owners provide remuneration by the total amount of cultivated land. As a result, the operators have no incentives to look after the machines, which caused frequent machinery breakdowns. The authors argued that the seasonal job contract of a farm machinery operator was why people are not interested in this particular job. Consequently, it is still difficult to find operators during the paddy growing season for some hire service providers in the survey areas.

c) Demands for Machinery Hire Services

It is widely agreed that the demand for machinery hire services by farmers is one of the essential factors in shaping the operation of machinery service providers. Machinery hire services tend to have seasonal needs, for which we can use the demand-supply algorithm. A survey of machinery hire services in Kampar Regency, Riau Province, revealed that seasonal demand is influenced by seasonal work, which varies across machine types and is controlled by tillage operation or land preparation.

Furthermore, the seasonal work of machinery is influenced by various factors, such as the total working days during the rice-growing season, water supply into paddy fields, and the limited number of machines available to farmers. Field conditions also influenced the work of machinery; these include field size and shape, weed population, and distance from the machining center to the farm. Likewise, a survey of farm machinery services in rural Shanxi Province, China, identified that land size, the degree of specialization on planting, and the availability of machinery service providers influenced demand for machinery services by farmers [80]. Furthermore, a study in Bangladesh found that different cropping patterns and diversified crop production because of different topography, fertility of land, and water resource availability are factors influencing the demand for tractors for tilling across time and seasons.

Additionally, service charges set by machinery service providers influence the demand for machinery hire services. For instance, the service charge of machinery service providers in Riau Province, and Sausu District, Central Sulawesi Province, are set lower than the Government's rate due to the low purchasing power of farmers and to increase their demand [81]. However, it is argued, as evidenced in their study in the Special Region of Yogyakarta, that if they are unable to set a profitable custom rate, machinery hire service providers lose their opportunity to generate profit from the business.

Migration to other areas by machinery service providers is another factor influencing the demand for machinery services. The number of working days of machinery services can be increased by migrating to other places, leading to more profits received by the providers. For instance, in Ghana, it has found that government-led machinery hire services (AMSEC) were infeasible because mainly these providers only provide local plowing services [73]. Conversely, in China, the provision of farm machinery services has increased the demand for machinery services by migrating across different agro-ecological conditions. The authors suggest that through migrating to neighboring villages, the annual use of tractors can be increased and eventually receive more profit. However, machinery service providers need first to understand the necessary conditions that will enable them to migrate, such as different harvesting times for the same crops across other areas, coordination problems, and infrastructure conditions such as roads.

Institutional Support

Institutional support has arguably influenced the performance of machinery hire providers. Institutional approval is needed to create a sustainable environment for introducing and sustaining the multi-fame use of machinery provided by farm machinery owners, including the machinery hire providers. Institutional support arrangements will vary across developing countries and may be grouped according to the type of activity and service provided. The institutional supports are financial/credit services, extension services, training for machinery operators. Many scholars have provided empirical evidence of these institutional supports in influencing the operation of machinery hire providers. These institutional supports are discussed in the following section.

a) Access to Financial Credit Support

Financial assistance in credit or subsidies is arguably an effective means to support agricultural mechanization in developing countries. For most smallholder farmers in these counties, not owning farm machinery is a result of low purchasing power and because purchasing agrarian machinery is an investment decision. It may not suit them because the returns on investment are unlikely to cover the investment Tools. Implements and farm machinery requires an initial capital investment. This reason has usually become the justification for the public sector to intervene and provide machinery subsidies to farmers, as experienced by many governments. In many countries, government subsidies are usually in the form of capital grants and low-interest loans.

Financial support provided by the governments in developing countries can set the pace and direction of agricultural mechanization. Meanwhile, in India, because of farmer low purchasing power, the government has made credit available at a reduced rate to assist farmers in procuring agricultural machinery. Private sector can provide financial aid to farmers so that they can purchase agricultural machinery. In Thailand, machinery hire services use local and foreign commercial banks to borrow funds to develop their business. Similarly, a study in Bangladesh found that the providers of the custom hiring of the power tiller operated seeders (PTOS) have utilized more help from commercial banks and other lenders than before because the business is profitable.

A frequent problem arises when providing financial support to small-scale farmers because small farmers cannot cover interest and loan amortization due to not having an off-farm income. Their farm production is sufficient only for their consumption. Farmers can overcome this problem if they possess agricultural machinery such as tractors and provide machinery services to start earning income and paying the loan. Therefore looking at the lack of capital for smallholder farmers, it is argued that financial support from the government may be a viable option for them to own farm machinery in the early stages to overcome investment constraints. It is suggested that the role of government should only be to stimulate the mechanization process and to emphasize the demand side by keeping financial support relatively small to avoid rent-seeking behavior.

b) Access to Agricultural Extension Services

According to FAO, agricultural extension services provide information to farmers and operators on the use of farm machinery and mechanization problems in general Along with the provision of specialized training facilities [82]. In China, strong Agricultural extension services have made mechanization available for small-scale farmers in the country [83]. Access to agricultural extension services is arguably influencing the operation of machinery service providers. High-quality extension services can effectively provide technical and business training to farmers. The efficacy of the extension service provision involves adequate and timely access by farmers. To adopt new technology or new farm practices, farmers tend to accumulate information to improve their knowledge before adopting new technology. As one way to obtain information, contact with extension agents in training and visits can be expected to stimulate farmers to adopt the technology. This technology adoption can increase the farmer awareness and knowledge of the potential benefits of available technologies. Farmers who have had contact with extension agents are likely to benefit from extension services.

Previous studies have identified that contact with the extension agencies and vice versa are essential in influencing the adoption of technology. A study in Ondo State, Nigeria revealed that the frequency of extension visits, the level of education, and access to farm machinery were significant determinants of adoption of mechanization practices [84]. In Bangladesh it was found that contact with agricultural extension was one of the important influences in the adoption of raised bed technology for cultivating crops by farmers.

However, there are some challenges for farmers and extension agents to establish regular contact, particularly in developing countries; such challenges are adequate infrastructure, like rural road networks and communication infrastructure. Poor rural road networks increase cost and difficulty for extension agents to reach farmers. Furthermore, it is difficult for farmers to adopt improved technology if their geographical position prohibits vehicle access. Similarly, inadequate communication infrastructure affects farmer access to mass media, such as publications, radios, or television, which extension agents provide. Extension agents may have insufficient access to telecommunication infrastructure, which affects them in conveying messages to farmers. However, good infrastructure conditions can increase farmer technology adoption as evidenced in Bangladesh.

c) Training for Machinery Operators

It is argued that ensuring farmer's access to technical information is crucial for the development of machinery hiring services at the farm level, because many farmers acquire limited technical knowledge of tools. The farm machinery operators in developing countries are often low, which could lead to conflicts during operations and reduce the quality and efficiency of work and decrease the economic life of machinery. Farm machinery operators gain operating and maintaining machinery skins through on-the-job training and trial and error. They commonly learn these chills from other operators, or are supervised by family members.

Large farmers initially used mechanized technology, followed by medium-sized farms. Many farms across different states fostered profitable agricultural equipment and implemented supply and services business. These farmers are also the ones who created mechanization. Farmers who purchased agricultural mechanization inputs benefited from off- and on-farm bespoke hiring options, as well as guaranteed support rates for their output. The manufacturing industry grew as farm machinery and equipment required high effective demand, resulting in India being a world leader and net exporter in this area. Several state agricultural institutions have contributed to the achievement of agricultural mechanization in India.

Combining an optimal machinery system is not straightforward. Operational equipment may alter in usefulness from year to year due to climate variations or growing techniques. Design improvements may make older technology outdated. Also, the quantity of farmland or available labor might potentially alter. Since many of these factors are unexpected, the Good Machinery Manager's objective should be to build a flexible system just to react to a variety of weather and crop circumstances while reducing long-term costs and output hazards. Essential issues will have to be solved. For the investment to be worthwhile, the apparatus must work dependably in various field situations regardless of its cost. Tillage equipment should provide a good seedbed while also eliminating early weed development and limiting erosion. Seeders and planters should ensure uniform seed placement, population, and Pesticide/fertilizer application. Clean, undamaged grain must be harvested while reducing grain loss.

A machine's performance is dependent on operator proficiency or weather and soil conditions. Despite this, variations across machines may be tested, researched, and learned through firsthand experience. Choosing tillage, planting, weed control, or harvesting equipment is only the first step in the process of reducing equipment expenses. Larger equipment will often cause machinery ownership costs to be needlessly high over the long term, while smaller equipment may result in lower agricultural yields or poor quality. Machinery ownership costs include depreciation, interest on investment, taxes, insurance, and machinery housing costs. As equipment investment and size rise, so do the expenses. Fuel, lubricants, and repairs are operating expenses. Operating expenses fluctuate little if equipment size is raised or reduced. The more acres covered every hour, the greater the amount of gasoline and lubricants are used. The repair prices are mostly similar. As a result, running expenses are of minor significance when it comes to making equipment purchases.

The amount of time needed to do a field operation decreases as the machine capacity rises. The time required to complete machinery operations is calculated by the distance and travelling cost. Hourly or part-time employed labor that works devices should utilize the pay rate given, plus any extra perks supplied, as the total cost of labor. It is reasonable to value labor at its potential cost, or the projected return it might make if it were utilized elsewhere in the farm business, such as in cattle operations. Planting and harvesting may alter the quantity and quality of the crops. It constitutes a "hidden" expense, but it is critical nevertheless. These yield losses are frequently referred to as "timeliness charges."

Syed depicts that farm robots' scope in India study says our farm equipment companies and researchers have produced a lot of small and heavy farm equipment for conventional farming needs, but precision farming requires some kind of robotic and pneumatic mechanism [85]. Since robots have entered the fields described above, it is essential to consider why they have not yet entered the farming sector. If robots are used to manage weeds, it will help to minimize the use of herbicides and the produce will become organic. Robots can also be used to transplant seedlings to save time and effort.

As per a report by Dr. K.K. Singh, Course Director, Dr. P.C. Bargale, Co-Course Director, Dr. P.S. Tiwari, Co-Course Director in 2017 from Bhopal Smallholder farmer mechanization has been a major challenge, especially in developing countries [86]. Farm mechanization is essential to keep small farmers interested. Mechanization, on the other hand, must be tailored to the local socioeconomic and cropping trends. In the future, environmental problems will become more relevant. As a result, mechanization is critical for the effective implementation of conservation agriculture technologies. Many climate-smart technologies cannot be implemented without the implementation of appropriate mechanization. Another critical problem for developing countries is the robustness and affordability of smart technology.

A review of the business models of two new custom machinery and equipment rental agencies in Punjab reveals substantial demand for such services from small farmers. in general, as well as from other types of farmers, not own certain expensive machines at the individual farmer level [87]. As per p s Tiwari Farm's mechanization status in India has been described as a key factor in rising agricultural productivity globally. Since the Indian market is heavily dependent on rising agricultural production, farm mechanization must be promoted [88].

Frances Cossar study says tractor usage leads some farm households to increase the area under cultivation, increase labor use for some activities, and increase women's involvement in agricultural production, according to research [89]. These results suggest that due to the limited time for land preparation in Ghana motivates farmers to use concept of tractor plough. Farmers adjust their production decisions on which crop to plant and how much labor effort to spend in crop maintenance and harvest when mechanized plough is used, allowing for earlier planting. For farm households who are newly excluded from the tractor service market, these effects of tractor use are more pronounced.

Jianjun examines how businesses and farmers make optimum production and buy decisions in private under conditions of randomized output and unpredictable market demand, examining the ideal outcomes under optimal decision-making with mutual consideration of the parties in the situation of independence. When the price rises, the business will add additional goods to the wholesale market under fundamental criteria that have not altered. The industry continues to aspire to purchase more farmer goods, while farmers, under specific circumstances, determine how much they will automatically sell to the company to meet demand, which is determined by market prices [90]. If the contract price is met, the market price of soybeans will usually be provided to businesses, and the market price will represent the particular conditions. Then, we'll use the shapely model to analyze this supply chain and take a little step toward calculating farmer income; this may be a solid start.

Diksha Manaware in November 2020, in his study, described how dependence on unsustainable agricultural activities could only raise the risk of food shortages as climate change becomes more sensible and unpredictable [91]. Similarly, water consumption in agriculture tends to be excessive and sub-optimal. Agriculture uses 89 percent of harvested groundwater has just one-third of the gross cultivated area under irrigation [92].

The price realization is due to the lack of functional end-to-end agriculture supply chains. Artificial Intelligence technologies aid in the production of healthier crops, provide information on current weather conditions such as temperature, rain, weed intensity, weed direction, and solar radiation, and assist in managing workload [93]. Herbicide applications have a significant impact on human health and the environment. Via proper and precise weed control, modern AI methods are being used to reduce herbicide use. Rayda Ben Ayed and Mohsen Hanana depict Robotics' main objective in farming: to provide predictive decisions to increase yield while preserving resources. As a result, different tools propose different systems to evaluate results, identify patterns, and predict unexpected problems or phenomena to solve comprehension problems in the agriculture industry [94].

Ashok Gulati and Ritika Juneja September 2020, while detailing the major factors in Indian farm mechanization, focus on tractors. In India, there has been a big change away from conventional agricultural practices and mechanized methods. Remote power is used for various fieldworks, while stationary power is used for lifting water and running irrigation machines, threshers, cleaners, graders, and other post-harvest operations [95].

B. JothiJahnavi, R. Monica, N. Sripriya research study tells how Rental of Agricultural Equipment Small and medium landholding farmers in India are mainly looking to rent equipment on an hourly basis. The list of tractors and other equipment information will be shown in this module. We improve the use of agricultural equipment by leasing it from the owners, and we also pay higher rentals than they can get just by serving their current a client base. Stakeholders should expect more land fragmentation on hilltop farms, and as a result, intensive monocultures are impossible to foresee without serious social and environmental consequences. The custom hiring service is popular in Terai, especially for the use of tractors and threshers, but it is new in the hills.

Agricultural equipment, insect and weed control tactics, seed sowing, fertilizer and water applications, power production, animal feeding, and everything else in a farmer's toolbox is used in order to improve productivity and keep costs down. Agricultural equipment and the method of management usually allow up field of agrarian production. Most of the enhanced crop productivity documented over decades in farming is linked to machine and implement use [96]. A study by Oduma et al. discovered that farmers are very attentive to the volume and quality of the machines' operations to prevent the cost of hiring/purchasing or repair from rising. In other words, agricultural activities are timely and costly. Selection, optimization, and optimal farm scheduling are improved with machine access [97].

Oluka further said that knowing the different cost indicators linked with tractor and implement ownership allows farmers to know whether they are profiting or losing in the agricultural business with their tractors and tools [98]. In Withney’s opinion, successful machinery usage and management need a grasp of the statistical information on the machine efficiencies to fit a specific working time and to build a complete perspective of mechanization [99]. There are significant variances in operating circumstances, such as the terrain, hardness/coarseness of the ground, surface quality, and tractability of the soil; these may affect the running circumstances of the machine/instrumentation [100].

We all agreed that understanding the workflow of the implement/machine is critical. Information on equipment management and usage enhances the timeliness of agricultural activities and other economic elements [101]. Whenever you are asked about the performance of farm equipment, ask yourself that what kind of tasks is this equipment capable of doing within the timeframe. The tools and its attached parts are intended to perform jobs well in land preparation, mechanized weed, fertilizer application, pest/weed controls, and crop harvesting to reduce damage to crops; and provide a seed bed that is ideal for the plant while maintaining the soil moisture. Another important indicator in agricultural operations is energy.

As per Updhyaya et al., there is a need for a smart decision support system that promotes the renting and sharing of equipment in India. Mechanism would also lead to the creation of friendly social orders. Most analysts voted for custom listing instead of owing farming hardware, particularly for smallholder farmers, because of high risk [102]. Therefore, equipment operation should be simple, affordable, consistent, and fuel-efficient .matching implement size and speed of operation to machine size helps increase machine field capacitive performance. The efficiency of agricultural equipment in carrying out field activities and the output and quality of produce may typically be assessed. The running of the equipment is the pace at which the machine can complete a certain field operation within the allotted time. The researchers found that effective capacity is assessed by the amount of work implemented in hectares per hour, with indications of implement breadth and speed as well as allowances for time lost, for turning in the field, and maintenance of the implements. Mechanical efficiency describes how well the machine performs its duties. An experienced rancher is aware of the time for harvest because of the effects of bad operation or incorrect usage of the equipment. Anazodo et al. found that field capacity data of agricultural equipment varies significantly and must be considered when choosing equipment because of variations in agro ecological soil conditions.

Von Bargen et al. stated everything farming requires takes quite a lot of time. Timeliness refers the time it takes to begin, turn around, and sit idly. The influence of any virtual device relies on many different aspects, including theoretically field capacity of equipment, machine mobility and machine maintenance in the field [103]. Time loss and machine utilization are included in general field efficiency. Effective field capacity is the land covered or crops handled per unit time. Theoretical field capacity is the theoretical rate of performance at which a machine operates 100% of the time, using 100% of its working width.

This study conducted by Oduma et al. Examined technical specifications of different agricultural types of machinery in southeast Nigeria and discovered that the overall system performance of plough was 87.11%. In contrast, the average system performance of harrow, tractor, rotovator, and planter was 86.32%, 86.78%, 87.14%, and 86.81%, accordingly [97]. However, on clay loam soil, the maximum efficiency was achieved, with an overall efficiency of 86.53 percent; on sandy loam, the overall efficiency was 87.35 percent, and on loamy, sandy soil, the overall efficiency was 86.21 percent. Additionally, this furthers the conclusions of Jones, who proposed that soil type greatly influences plough performance. Despite a rigorous time study done by these writers, the equipment found on farms in the South-east area of Nigeria could not be covered. Tillage and planting equipment was their primary emphasis.

On sandy loam soil, Olatunji examined disc plough effectiveness at various moisture levels. The concept of dimensional analysis was implemented to generate model values for sandy-loam soil depth of cut, blade plough weight, and draught power [104]. Even with the comprehensive research, only one fertile soil and one tillage instrument were considered. In implementing these settings, users must be aware of differences in soil and circumstances. Finally, due to the various soil kinds and conditions, it was discovered that field efficiency statistics on various soil conditions are critical to tractor and tool choices. Thus, such information is not offered to agricultural practitioners or producers in Brazil (by implement makers) specifically for evaluation or possible testing of equipment before purchase [105].

Literature Review

Author (Year)	**Title**	**Findings**	**Relevance**
		Farmer Suicide in Punjab	
D. Grover, S. Kumar, J. Singh, and J. M. Singh, (July 2019)[8]	"Farmer Suicides in Punjab : Causes and Suggestions Study sponsored by Ministry of Agriculture and Farmers Welfare Agro-Economic Research Centre Department of Economics and Sociology.	• This paper depicts the different causes of the farmer's suicide • It provided the suggestions to improve the status of the farmers by providing them awareness of the new government policies and farming tools.	Farmer Suicide in Punjab:- Here we came up with data on farmer suicide in Punjab and their underlying reasons.
		Mechanization	
A. Sarkar, (2020) [21]	Agricultural Mechanization in India: A Study on the Ownership and Investment in Farm Machinery by Cultivator Households across Agro-ecological Regions	• Mechanized ploughing does not substantially reduce labour used for land preparation, and in turn increases labour usage for other operations, according to marginal users of agricultural machinery.	Mechanization: - We derived the need of mechanization and automation in India from these papers. The emphasis of farm mechanization is on improving agricultural productivity and enhancing availability of tools and Equipment's, and also reducing manpower scarcity.

Author (Year)	Title	Findings	Relevance
B. K. Ghosh, (2010) [22]	Determinants of Farm Mechanisation in Modern Agriculture: A Case Study of Burdwan Districts of West Bengal	• Mechanization's importance in agriculture has grown as it improves productivity by increasing input production, speeding up agricultural operations, reducing drudgery, and lowering the cost of cultivation.	
Custom Hiring Center in Punjab			
R. S. Sidhu and K. Vatta (2012). [23]	Improving economic viability of farming: a study of Cooperative Agro Machinery Service Centres in Punjab	• This Study emphasised on the various Cooperative agro machinery service centres in Punjab. • It addressed the importance of custom hiring centres in Punjab	We developed the concept of previously existing bespoke recruiting centers in India based on these papers. Additionally, it is necessary to educate farmers who reside in rural regions about custom hiring centers in India.

Author (Year)	Title	Findings	Relevance
S. P. Yarazari, (2019) [38]	Custom Hiring Services of Farm Machinery in India.	• This Study focus on various custom hiring services of farm machinery in India. • Due to their economic situation, small/marginal farmers are unable to acquire agricultural equipment on their own or via institutional finance. • As a consequence, custom hiring must be aggressively pushed in order for small/marginal landowners to access agricultural equipment.	
S. S. Chahal, P. Kataria, S. Abbott, and B. S. Gill, (2014) [41]	Role of Cooperatives in Institutionalization of Custom Hiring Services in Punjab	• According to this study, bespoke hiring enables needy farmers to gain the advantages of automation via the utilization of costly equipment. • Some cooperative organizations have taken the initiative to offer agricultural equipment services to farmers on a rental as well as a personalized hire basis •	

Author (Year)	Title	Findings	Relevance
Renting and Hiring of Equipment			
B. JothiJahnavi, R. Monica, N. Sripriya C. [42]	Efficient Farming – Hiring Equipment for Farmers	• Hire service equipment may also have several features, providing the farm family with even more advantages. • Farming becomes more competitive as yields and time savings increase, and costs can be reduced.	From these papers, we deduced the need of developing an uberized model for equipment rental and sharing.
Sukhpal Singh (2017) [50]	Inclusive and Effective are Farm Machinery Rental Services in India	• In some parts of India, realisation and local creativity have resulted in a trend of custom farm machinery rentals, which began in Punjab.	

Author (Year)	Title	Findings	Relevance
Machine Learning Algorithm			
H. H. Patel and P. Prajapati,(2018) [55]	Study and Analysis of Decision Tree Based Classification Algorithms	• The aim of this paper is to provide an overview of machine learning techniques that are currently being used or considered by methodological departments across the country. • In today's world, a vast amount of information is readily available. • As a consequence, it is important to evaluate such data in order to extract some valuable information and to build an algorithm based on this research	From these papers we introduced the concept of machine learning Algorithm:– Decision Tree Classifer/regressor
H. Sharma and S. Kumar (2016) [56]	A Survey on Decision Tree Algorithms of Classification in Data Mining	• To address the current issues in agriculture, a variety of strategies have been proposed, ranging from database development to selection assistance frameworks. • Structures that use decision tree classifiers have been found to be the most excellent performers in terms of accuracy and robustness among these solutions.	

Author (Year)	Title	Findings	Relevance
Recommendation System			
M. B. Santosh Kumar and K. Balakrishnan(2019) [59].	Development of a model recommender system for agriculture using apriori algorithm	• In this paper two approaches content based filtering and Collaborative based filtering is discussed by the researcher. • Collaborative based filtering widely used in the building of recommender systems. • CBL approaches are referred to be memory-based and model-based.	From this paper we incorporated the concept of recommendation system on the basis of rating and searching of products
Supply Demand based Optimization			
W. Zhao, L. Wang, and Z. Zhang, (2019) [61]	"Supply-Demand-Based Optimization: A Novel Economics-Inspired Algorithm for Global Optimization.	• In this paper authors focused on Equilibration methods which may be utilized to address a range of supply and demand issues are implemented in this study. • This kind of algorithm attempts to equilibrate the whole system by equilibrating sequentially each supply market (producer) or each demand market (consumer).	We presented the idea of demand and supply algorithms and demonstrated how to optimize demand based on supply and seasonal variations through these studies.

Author (Year)	Title	Findings	Relevance
Supply Demand based Optimization			
L. Fleischer, R. Garg, S. Kapoor, R. Khandekar, and A. Saberi, (2016) [62].	A simple and efficient algorithm for computing market equilibria	• The supply- demand- based optimization (SDO) method, which is a new meta-heuristic optimization technique, is described in detail in this paper. • SDO is a swarm-based optimizer designed to optimize supply-demand relationships.	
Jianjun Yu, Qiangqiang Zhu (2015) [90]	Agriculture Production Planning Under Supply Uncertainty and demand Uncertainty	• This paper focuses on the demand and supply algorithm optimization on a particular market of a crop. • The study focus on how the market and the company make optimal decision to improve the productivity	Demand Supply Optimization with Seasonal Fluctuations

2.5 SUMMARY

This chapter includes the literature survey of the selected problem. This literature covers the information for the last approximate 10 years. This chapter supports the researchers for the origin of the problem of the farmers which include the cause and effect of the selected problem. To view this herein literature has been surveyed. The surveyed literature focused on the view of the researchers over the whole globe. The reason of suicide of Punjab's farmers has been included in it. Mechanization helps the farmers to improve their yield. The need of custom hiring centers is very important which helps to enhance their knowledge. To solve the issues of the farmers uberized model plays a vital role. This will help the each category of farmers for renting and sharing of equipment. From the survey also we came up with the novel idea of recommendation system and the demand supply algorithm that is implemented in the proposed system. In the nut shell, in this chapter we have found that there are step by step procedures to cover all the necessary aspects for the farmers which will support them in the future.

Chapter – 3

RESEARCH METHODOLOGY

This chapter outlines three sections which include the adopted procedure for Development of Internet based Smart Agricultural Resource Sharing Framework. In the first part of the study, data collecting was done.The collected data was taken from 562 farmers in Punjab's Malwa, Majha, and Doaba areas. Our projections show that the demand for equipment renting and sharing will be high. A system where users must register before they are allowed to rent or hire any equipment has been created using machine learning in the second part. We implemented the concept of Recommendation Engine for Optimized Search based on price, name, Month and location. The supply-demand-based optimization (SDO) method, which is a new meta-heuristic optimization technique, is described in detail in this section. SDO is a swarm-based optimizer design. An Internet-based mobile application that enables the end-users to promote, reserve, rent, and share agricultural equipment was created in the third phase.

3.1 DATA COLLECTION

Farmer fluctuations are driven by the multitude of factors that primarily include educational qualifications, age, yearly income, spending, the number of family members, lack of technical expertise, the load of debts, and many other contributing factors.

The foregoing concerns contributed to the demise of farming in India. Considering this issue, in this present study a socio-economic study is undertaken in Punjab and a technical solution is found to encourage agricultural equipment rental and sharing. This chapter includes methods and methodology used for the development of internet based smart agricultural resource sharing framework. The purpose of this research is to modify the farming production in Punjab. For this, recent supplementary data has been gathered and interpreted from a wide range of sources. In this applied research we gathered the data from 562 farmers in Punjab from different districts, villages of Majha ,Malwa and Doaba regions of Punjab. The data has been collected by an open end Questionnaire which includes various parameters as shown in the figure 3.1.The questionnaire was created in English and Punjabi language taking in concern the education level of the farmers. This Questionnaire is attached in the annexure 1.The purpose of this collected data is to explore the major concerns faced by the farmers. By the parameters loan source, reason of loan, wish to hire machinery, interested in mobile application we anticipated the need for renting and sharing of the equipment's.

	A	B	C	D	E	F	G	H	I	J	K	L
1	1	2	3	4	5	6	7	8	9	10	11	12
2	NAME	VILLAGE	LAND	AGE	GENDER	EDUCATION	FAMILY	PER MONTH	AGRI	FARMER	FARM	AWARE OF NEW
3	BUTA SINGH	BANGER MUHABAT	3 ACRES	38	MALE	GRADUATE	4	10000-25000	18	SMALL	NO	YES
4	GURDEV SINGH	BANGER MUHABAT	1 ACRES	40	MALE	SECONDARY	4	10000-25000	20	SMALL	NO	NO
5	GURJANT SINGH	BANGER MUHABAT	2 ACRES	39	MALE	SECONDARY	6	25000-50000	19	SMALL	NO	NO
6	MAHINDER SINGH	BANGER MUHABAT	3 ACRES	44	MALE	SECONDARY	5	25000-50000	24	SMALL	NO	YES
7	MEJOR SINGH	BANGER MUHABAT	3 ACRES	48	MALE	SECONDARY	6	25000-50000	28	SMALL	NO	YES
8	PARMINDER SINGH	BANGER MUHABAT	6 ACRES	55	MALE	SECONDARY	5	25000-50000	35	MEDIUM	NO	YES
9	GURTEK SINGH	BANGER MUHABAT	5 ACRES	60	MALE	GRADUATE	5	25000-50000	40	MEDIUM	NO	YES
10	RAJINDER SINGH	BANGER MUHABAT	5 ACRES	39	MALE	SECONDARY	4	10000-25000	19	MEDIUM	NO	YES
11	PARAMPAL SINGH	BANGER MUHABAT	7 ACRES	52	MALE	SECONDARY	4	10000-25000	32	MEDIUM	YES	YES
12	GOBIND SINGH	BANGER MUHABAT	3 ACRES	54	MALE	SECONDARY	5	25000-50000	34	SMALL	NO	YES
13	BANTA SINGH	BANGER MUHABAT	5 ACRES	39	MALE	SECONDARY	4	10000-25000	19	MEDIUM	NO	YES
14	HARBANS SINGH	BANGER MUHABAT	6 ACRES	52	MALE	GRADUATE	6	25000-50000	32	MEDIUM	NO	YES
15	PARGAT SINGH	BANGER MUHABAT	4 ACRES	50	MALE	GRADUATE	3	10000-25000	30	SMALL	NO	YES

	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
1	16	17	18	19	20	21	22	23	24	25	26	27	29
2	UNDERGONE	OWN TOOLS	REASON OF LOAN	DO YOU NEED	CONSIDERABLE	INCOME FROM	LOAN SOURCE	NEED OF COLD	WOULD YOU LIKE	DO YOU FIND IT	DO YOU ATTEND	INTERESTED IN	DO YOU UI
3	AGRICULTURE	PLOUGH	PLANTATION,	YES	5	50000-200000	COOPERATIVE	NO	YES	YES	YES	YES	NO
4	AGRICULTURE	NO TOOLS	NO LOAN	YES	NO TOOLS	50000-200000	NO LOAN	NO	YES	YES	NO	YES	NO
5	NO	NO TOOLS	PLANTATION,	YES	NO TOOLS	50000-200000	COOPERATIVE	NO	YES	YES	NO	YES	NO
6	AGRICULTURE	PLOUGH	NO LOAN	YES	5	50000-200000	NO LOAN	NO	YES	YES	YES	YES	YES
7	NO	PLOUGH	PLANTATION,	YES	10	50000-200000	COOPERATIVE	NO	YES	YES	YES	YES	NO
8	AGRICULTURE	PLOUGH,TRACTOR	NEW MACHINERY	YES	5	200000-500000	GOVERNMENT	NO	YES	YES	YES	YES	YES
9	NO	PLOUGH,TRACTOR	LAND DEVELOPMENT	YES	10	200000-500000	COOPERATIVE	NO	YES	YES	YES	YES	YES
10	NO	PLOUGH,TRACTOR	LAND DEVELOPMENT	YES	5	200000-500000	COOPERATIVE	NO	YES	YES	YES	YES	YES
11	AGRICULTURE	PLOUGH,TRACTOR,CUL	NEW MACHINERY	YES	5	200000-500000	GOVERNMENT	NO	YES	YES	YES	YES	YES
12	AGRICULTURE	PLOUGH	PLANTATION,	YES	10	50000-200000	COOPERATIVE	NO	YES	YES	YES	YES	YES
13	AGRICULTURE	PLOUGH,TRACTOR	NO LOAN	YES	5	200000-500000	NO LOAN	NO	YES	YES	YES	YES	YES

Figure 3.1: Snap Short of Sample Collected Dataset.

To know the financial and educational situation of farmers in Punjab, a survey was done using Google Forms as well as door-to-door questioning. Figure 3.1 shows the study from the sample count of 562 number of farmers from majha district of Punjab shows that most of the farmers are having small to medium landholdings and the farmers are not educated enough to know the latest techniques or latest farming mechanization which can help them in getting more revenue from the same farming land.

Table 3.1: Detail of Category of Farmers

Sl. No.	Category of farmers	Percentage (%)
2	Small	67.06%
3	Medium	31.08%
4	Large	1.06%

Manually obtained data infers the need of rental and sharing of equipment. It includes several contributing aspects such as they are drowning in debt, ignorance of technical options, and government regulations. Therefore during the harvesting period, they are unable to use the equipment owing to its high demand. Farming operations also rely on a lot of bank loans and financial support. Financial inclusion is critical for farmers. The financial inclusion gap for India's farmers remains persistent, despite several initiatives. Most farmers commit suicide due to their financial load, which is further aggravated by various indirect factors. Banking facilities are tough to get for small and marginal farmers. As mechanization, as well as the underutilization tendency, raise production costs or reduce net returns to farmers, farming becomes expensive.

Equipment is costly to purchase and maintain, above that the monthly/yearly EMI add-ons to the loan. A farming equipment rental for agriculture aims to provide small farmers who cannot afford to buy costly machinery with access to modern technology. It will increase farmer income through increasing productivity by farm mechanization. Farmers won't have to purchase tractors or other vehicles because they'll be available for rent at a fraction of the cost of ownership.

Farmers who cannot afford to buy high-end agricultural machinery and equipment can hire farm equipment and machineries from Custom Hiring Centres. Custom Hiring Centres is an effective mechanism for most small farmers to gain access to agricultural machinery services. In Custom hiring Farmers don't have to worry about start-ups costs or repair and maintenance costs. They only paid for chargeable services and personalized service prices. Literature reported that the custom hiring centres has the potential application for renting and sharing of equipment.

After reviewing the many challenges encountered by farmers, we've built a support structure Smart tillage that helps farmers in renting and sharing of equipment.For this renting sharing of Equipment's we have implemented the concept in python language. The systematic steps to establish the information management system, is implemented by artificial intelligence and machine learning algorithms. The classification of the machine learning falls in different categories such as linear regression, Instance based model, clustering, decision tree and many more. We have developed a model that embeds the decision tree, which would provide the ideal solution for farmers. Decision trees are helpful because they require us to think about all conceivable outcomes and follow each route to a conclusion. It gathers and analyzes information across the branches to identify decision nodes for additional study.

In the model presented, researchers have worked in two sections: one in collecting the data of the farmers, and the other will incorporate it all into the Django system. The first section of this includes the information of 562 farmers from different parts of Punjab, as well as their conclusions depending on different parameters. This research study will help in the establishment and implementation that can be used to determine farmer demand and specifications for resource sharing and the hiring of agricultural tools and equipment. The systematic steps to establish the information management system, is implemented by artificial intelligence and machine learning algorithms.

The first component of our developed model is data collection, and the second framework deployment. Throughout the first section, we have collected from almost

562 farmers from different villages of Punjab areas about resource sharing and the hiring of agricultural tools and machines as shown in figure 3.2. Following that, a variety of formulas and mathematical expressions will be used to determine the likely price per hour of machinery and equipment, as well as the benefit to machinery owners. Using this data we have developed an efficient resource sharing and renting framework in the second part of the technique. Furthermore we have also developed an internet based agricultural resource sharing mobile application. In figure 3.2 Data preprocessing techniques include reading data, checking for the missing values, checking for categorical data and data splitting.

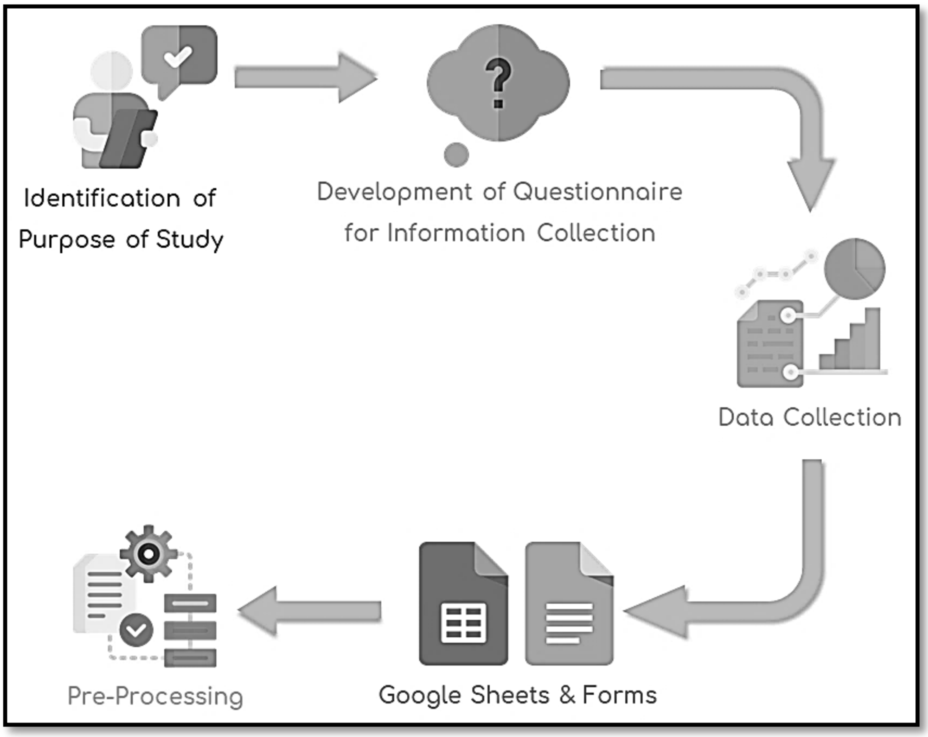


Figure 3.2: Data Collection Process (Pre-processing)

3.2 IMPLEMENTATION

To overcome the above said issues faced by the farmers we have developed a framework Smart tillage for renting and sharing of tools and equipment's. The framework connects farmers to buy and sell used equipment and services by making it easy for anyone to post a classified ad on their phone or on the internet. Agricultural Tractors, Agricultural Trolleys, Agricultural Sprayer Pumps, combines, and a wide range of other equipment are regularly checked and supplied by a large number of farmers in nearby markets throughout India.

Smart-Tillage is a platform where user has to register before they get permitted to rent or Hire any equipment through this application, which has been developed using machine learning for the data-manipulating and designed in Django 13.2 for front-end and Database used is the latest technique i.e Postgre SQL for better security and data processing.

On the produced data set we have used machine learning to estimate how many farmers are interested in hiring the tool. We have separated the data set into two parts training data set and the test dataset. 80 percent of the data is trained and 20 percent data is tested from the trained model to assess the correctness of the model.

3.2.1 Machine Learning Workflow

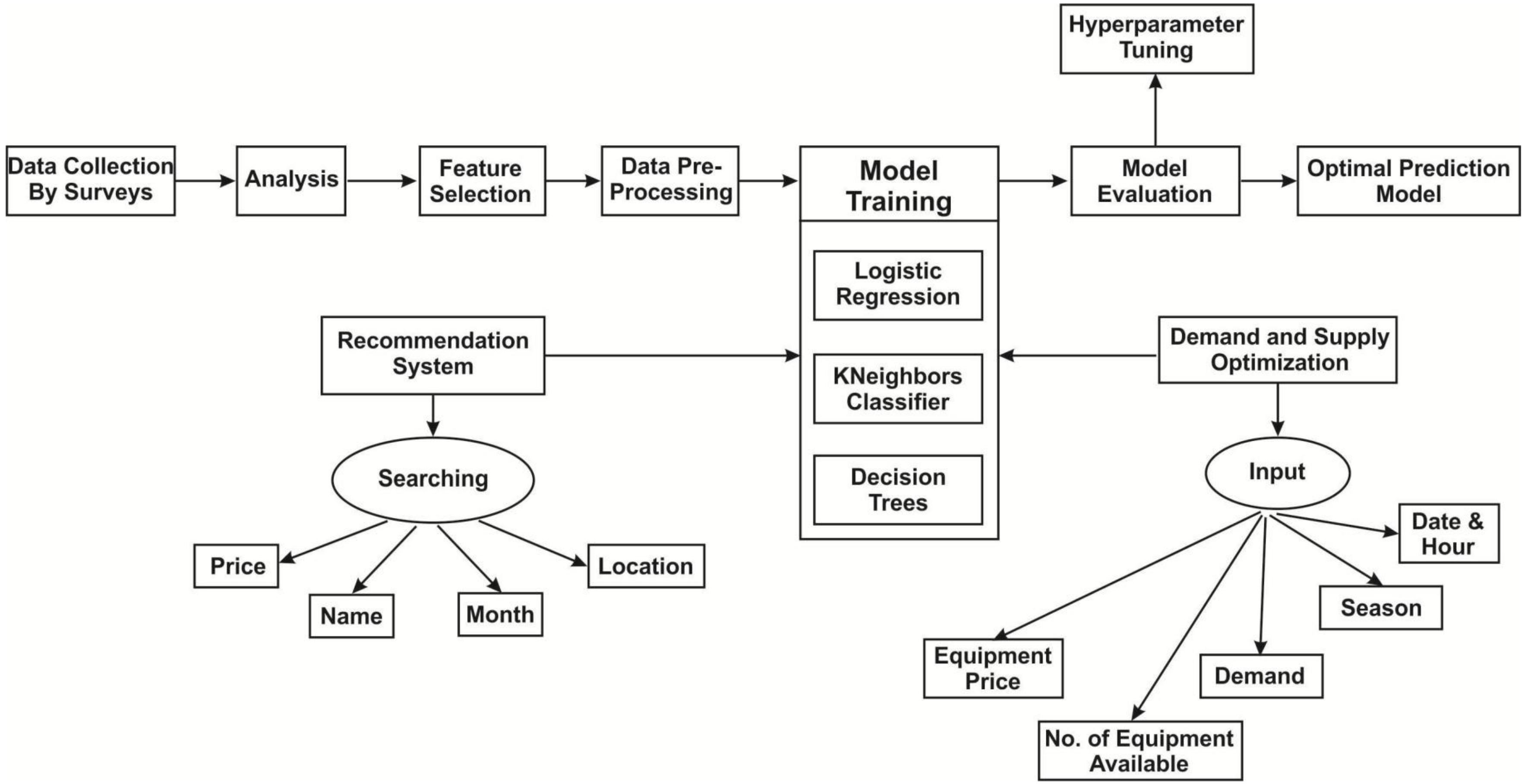


Figure 3.3: Accuracy Model

The model in figure 3.3 utilizes farmer data as input, in which many criteria including land, income from agriculture, per month expenditure, aware of new technologies, availability of loan, usage of smart phones, and information on interested users are examined. In this the comparison is done with the three techniques.

- Logistic Regression
- K Neighbors Classifier
- Decision tree

The embedded decision tree classifier is situated at the core of the system and is the heart of the entire application. The rule engine takes into account all the various parameters provided by the requesting farmer and scours through the rule engine to find the appropriate owner of the above said equipment. The Model is embedded with specific rules, to come up with better solutions. The rule engine also provided optimal results if the number of rules keeps increasing, provided the rules do not clash with each other. A basic binary tree is used to model the decision tree. Each node represents an input variable / parameter along with a decision factor at the core of it. The decision factor is basically a where / if clause which makes a decision using the rules from the rule engine. The path to be taken from the node would depend on the output from the rule engine. In this way, the final decision taken would be obtained by cruising through the tree nodes and taking optimal paths at each node until we reach the end of the tree which would be the leaf node. In the process of taking optimal paths, we also store sub-optimal paths which could possibly lead to good decisions and show them as recommendations to the farmer too, so that the farmer is free to choose whichever option suits him best. This model would improve quality of life by bringing them together for win-win trades. Farmers can gain some extra cash without much effort by simply posting items that are no longer in use, giving them the opportunity to find equipment at reasonable prices. The steps for the Proposed algorithm are as follows:-

Step 1:-Input the Farmers data into the system

Step 2:-Dropping the duplicate columns

Step 3:-Understanding the target variables

Step 4:- Initialize and Fit the Model

Step 5:- Predicting the values of test data

Step 6:-classification reports

Step 7:- Model Evaluation

Step8:-Depicting Accuracy

Algorithm I : Decision Tree

```
INPUT: S, where S = set of classified instances
OUTPUT: Decision Tree
.Require: S ≠ Φ, num_attributes > 0
Procedure BUILD TREE
Repeat
  maxGain <- 0
  Split A <- null
  e <- Entropy(Attributes)
For all attributes a in S do
    Gain <- Information Gain (a, e)
    If gain > maxGain then
      maxGain <- gain
       splitA <- a
        End if
    End for
    Partition(S, split A)
  until all partitions processed
End Procedure
```

3.3 OPTIMIZED SEARCHING AND RECOMMENDATION MODULE BASED ON USER REQUIREMENTS

On the Internet, where the number of choices is overwhelming, there is need to filter, prioritize and efficiently deliver relevant information in order to alleviate the problem of information overload, which has created a potential problem to many Internet users. Recommending systems solve this problem by searching through large volume of dynamically generated information to pro- vide users with personalized content and services. For the recommendation process following phases will be used:-

- Information Collection Phase
- Explicit Phase
- Implicit Phase
- Learning Phase
- Prediction/Recommendation Phase

Information collection phase will provide recommendations to the end user/farmers. Relevant information will be taken including farmer parameters like cost, equipment type, distance, availability, seasonal fluctuations and many more. In the explicit phase, the system encourages farmers to offer ratings for tools by prompting them via the system interface. Recommendation accuracy relies on the number of ratings supplied by farmers. In the implicit phase, the system automatically infers the community ’s needs by keeping track of various activities, such as the record of transactions, page navigation, and time spent on internet sites, links clicked, and e-mail information. Implicit feedback decreases the load on users by getting user preferences from behavior. Herein, the system will apply a learning algorithm to filter and explore the farmers need from the historical data. It suggests or forecasts the user's Equipment/tools preferences. Either directly, based on the dataset that was gathered during the information gathering phase, or from observing user behavior through the system, it may be produced.

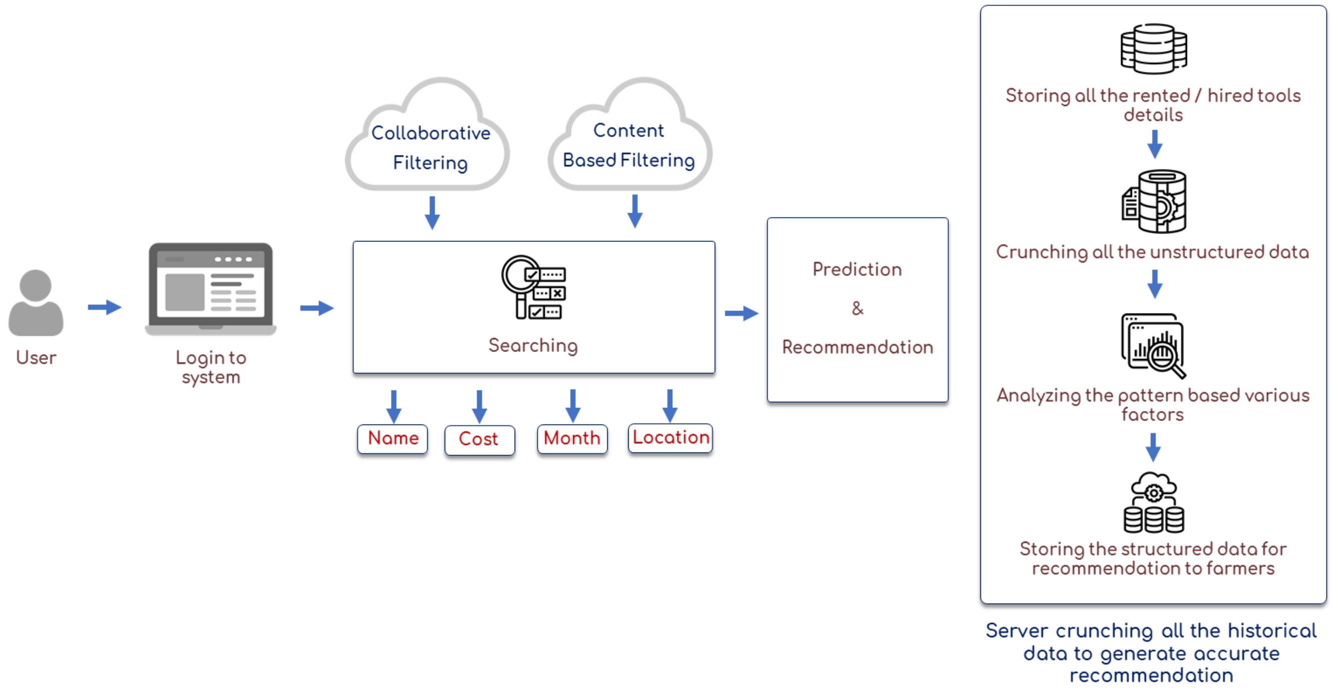


Figure 3.4: Recommendation Engine for Optimized Search

Step 1: User Login into system *Step 2: Click on searching Module* *Step 3: Enter the name of the Equipment* *Step 4: System apply filter on the basis of parameters entered and user rating* *Step 5: Provide the best recommendation to the user*

Algorithm II : Recommendation and Optimized Searching
Input : Number of Items to be recommended $N \in \mathbb{N}$, Number of neighbors used for ranking $k \in \mathbb{N}$, User to recommend items to *u*, List of all items *Items*, User-Item matrix of ratings *R* **Output** : *N* items to be recommended i) **for each** *item* $\in$*Items* **do** ii) **if** *item* $\notin$ *u.rated_items* then iii) *item.rank* $\leftarrow$rank.according_to_nearest_neighbors (*k*,*u*,*item*) iv) descending_rank_sort (*Items*) v) **return** top(*N*,*Items*)

Based on the selected system, there are two types of recommendations. Content based and collaborative based recommendation. Farmer recommendation is related to the parameters search by the user. Figure 3.4 depicts the recommendation engine for optimized search. For illustration, if a user want to search a harvester by giving the inputs like price, distance and specifications etc. Our system can provide the recommendation to the end user /farmers. On the flip side, for the collaborative based recommendation the user will provide the rating to the system and based on the behavior of the user the system will provide the recommendation.

3.4 SUPPLY DEMAND

Equilibration methods which may be utilized to address a range of supply and demand issues are implemented in this study. This kind of algorithm attempts to equilibrate the whole system by equilibrating sequentially each supply market (producer) or each demand market (consumer). Of particular significance is that these algorithms provide explicit, limited equilibria for each supply and demand market. Computational findings show that the methods are effective and appropriate for large-scale issues. The supply-demand-based optimization (SDO) method, which is a new meta-heuristic optimization technique, is described in detail in this section. SDO is a swarm-based optimizer designed to optimize supply-demand relationships. This algorithm simulates both the demand-supply relationship of customers and the supply-demand relationship of manufacturers. Figure 3.5 depict the supply demand optimization.

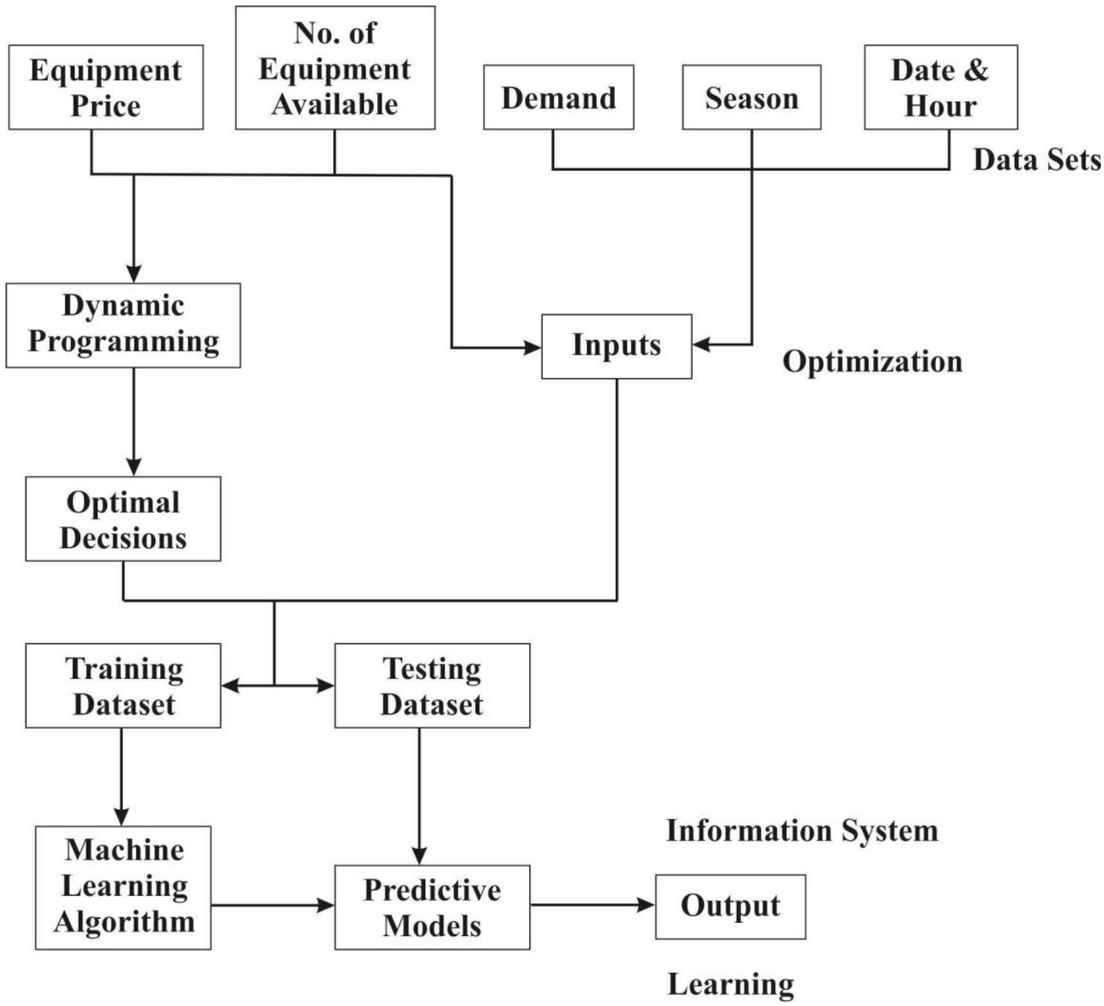


Figure 3.5: Supply Demand Optimization

3.4.1 Supply-Demand Interaction

To utilize this system, the user will post his item to the system. In the peak months of April and October, equipment demand is high. Every farmer holds this belief: Harvesting your crop when it's ready subsequently increase yield. In this demand supply method, the equipment is counted, and the number of users who wish to have access is computed. When demand for the equipment is higher, the price will rise. Algorithm generates an estimated equilibrium in iterations that are independent of the number of buyers and proportional in the number of tools.

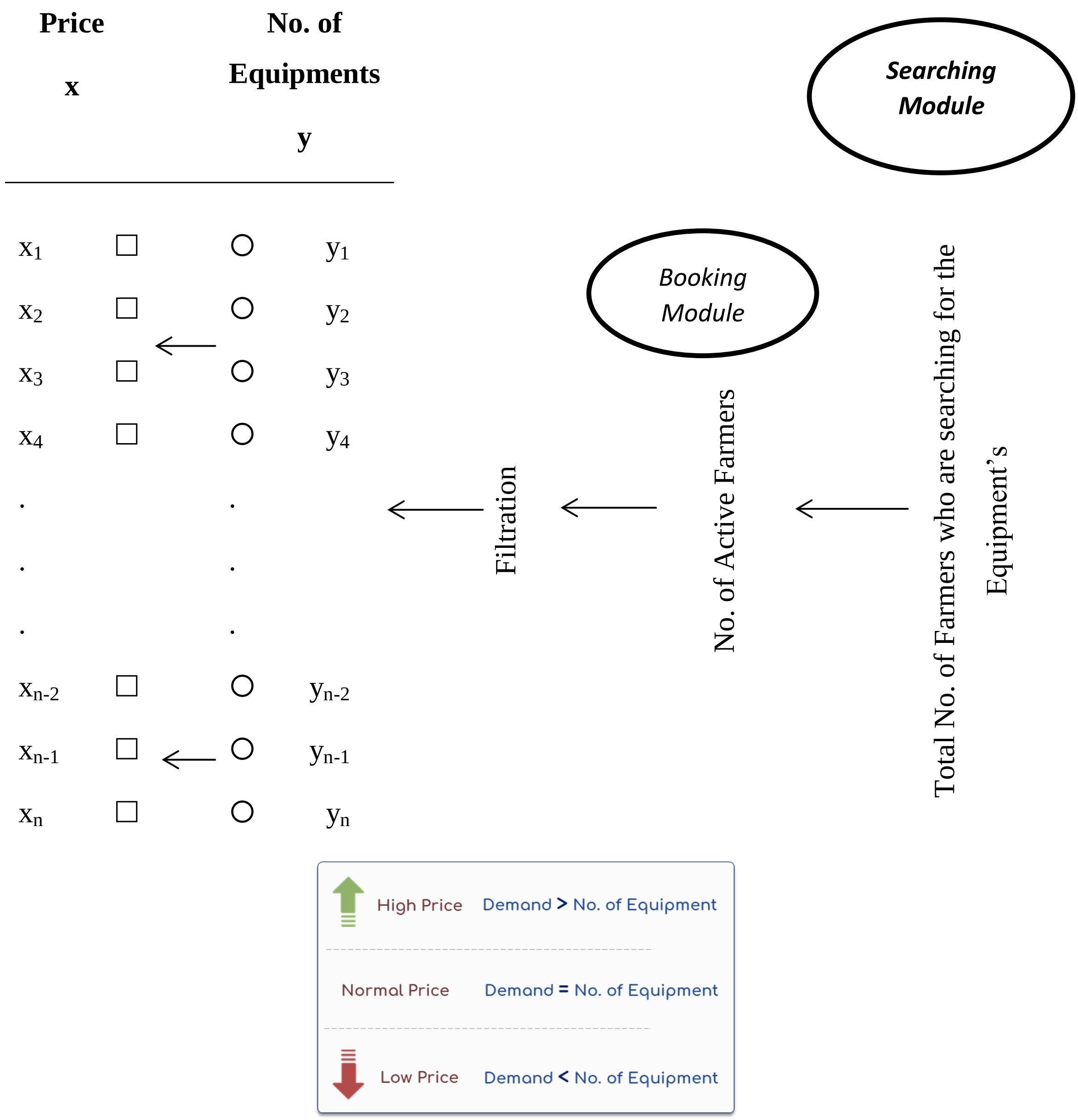
Suppose SDO is running in *n* locations, each of which contains *d* distinct number of items, and each sort has a set quantity and price as shown in figure 3.6. The commodity prices in a market reflect a potential solution for the optimization issue; therefore commodities in that market are evaluated as a possible solution. The best feasible solution will be selected and the existing solution will be replaced. Since it is a swarm-based approach, the commodity price and the commodity quantity are found in two matrixes. The matrix for the tool with price is given as shown in equation below

$$X = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} x_1^1 & x_1^2 & \cdots & x_1^d \\ x_2^1 & x_2^2 & \cdots & x_2^d \\ \vdots & \vdots & \vdots & \vdots \\ x_n^1 & x_n^2 & \cdots & x_n^d \end{bmatrix} \tag{1}$$

d is the actual number of equipment with price in each market x^j (i=1,2….*n*, *j*= 1,2,3…*d*) and *n* is the optimized price of the tool after imposing demand and supply algorithm. The Quantity matrix for market users is given as shown in equation below

$$X = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} y_1^1 & y_1^2 & \cdots & y_1^d \\ y_2^1 & y_2^2 & \cdots & y_2^d \\ \vdots & \vdots & \vdots & \vdots \\ y_n^1 & y_n^2 & \cdots & y_n^d \end{bmatrix} \tag{2}$$

Where d is the no of users logged in the system and n is the no of active users.



- *No. of Active Farmers represents the farmers who have booked the equipment.*
- $y_1, y_2, \ldots y_n$ *represent the different types of equipment.*
- $x_1, x_2, \ldots x_n$ *represent the equipment with price.*

Figure 3.6: Price Prediction Based on Supply demand

To estimate the commodity price and supply in system, the fitness function is used. Each price vector stores the return value of the fitness function for the recent study.

Every commodity quantity vector contains a fitness value computed by the solution that serves as a market supply- demand.Figure3.7 depicts the data flow of proposed work

The pseudo code used for demand and supply algorithm is

Algorithm III : Algorithm for Supply Demand Optimization

1. *Start*
2. *Identify the Equipment Demand(ed), weather forecast(wf),supply(s)*
3.
4. *While the criteria is not fulfilled*
5. *For each market i=1,2,3.........n*
   a) *Determine the total number of farmers who searched and booked the equipment's* y_0
      i) *Filter the no of farmer who booked a specific equipment's* y_1
   b) *Determine the total number of equipment's with price* x_0.
      i) *Filter the booking of specific Equipment with price number* x_1
6. *Calculate their fitness value* ***f(x1)*** *and* ***f(y1)*** *by using decision tree regreessor*
7. *If* ***f(y1)*** *is greater than* ***f(x1)***
   a) *Replace* ***xi*** *by new price* x_{i+1} *according to the MAE Value predicted by the model*
8. ***Else***
9. *If* ***f(x1)*** *is greater than* ***f(y1)***
   b) *Replace* ***xi*** *by new price* x_{i-1} *according to the MAE Value predicted by the model*
10. ***Else***
11. *If* ***f(x1)*** *is greater than* ***f(y1)***
   c) *No change*
12. *End if*
13. *End if*
14. *End if*
15. *End for*
16. *Update the best solution found so far according to predicted model*
17. *End y*

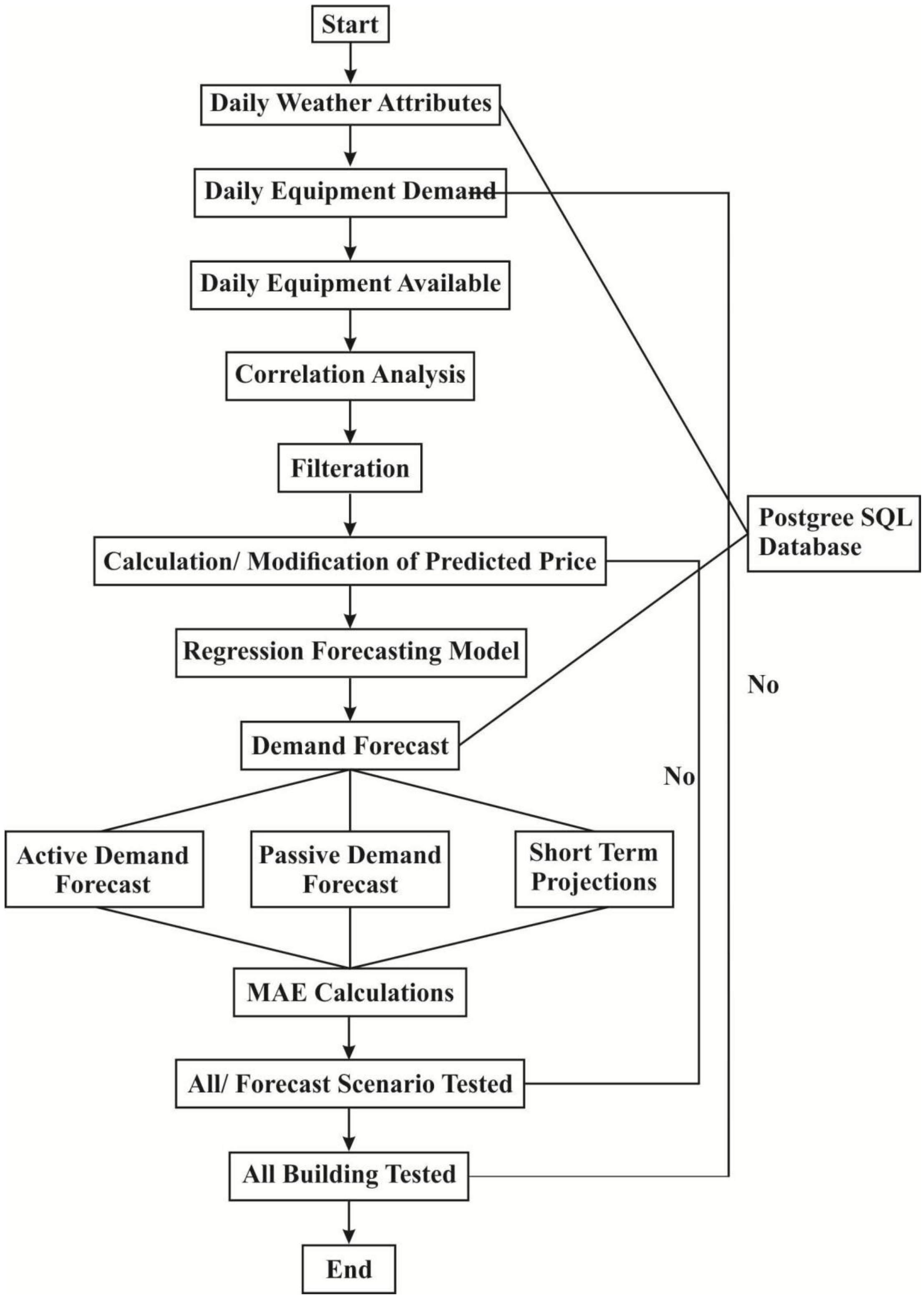


Figure 3.7 : Flow of Demand Supply

3.4.2 Types of Forecasting Techniques

A) Active Demand Forecasting

Active demand forecasting is utilized mostly by fast-growing startups and enterprises. Additionally, aggressive expansion goals like marketing or product development and the overall competitive climate are all taken into consideration in the active approach. The active demand forecasting forecasts price fluctuations based on farmer search for equipment and the number of tools available.

B) Short-Term Projection

Short-term demand forecasting works with a short time period to inform the day-to-day. Furthermore, it's helpful for JIT supply chains or product catalogs that constantly change. This forecast is used for day-to-day predictions.

C) Passive Demand Forecasting

Passive demand forecasting (PDF) is the most basic method. By using historical sales data, the future is projected. With fluctuating business, this is especially true. With quality sales data, the passive forecasting model performs quite well. Moreover, this approach is useful for companies who want stability over development. It is a model that predicts this year's sales will be equal to last year's sales. PDF is simpler since it doesn't utilize statistical techniques or examine economic trends.

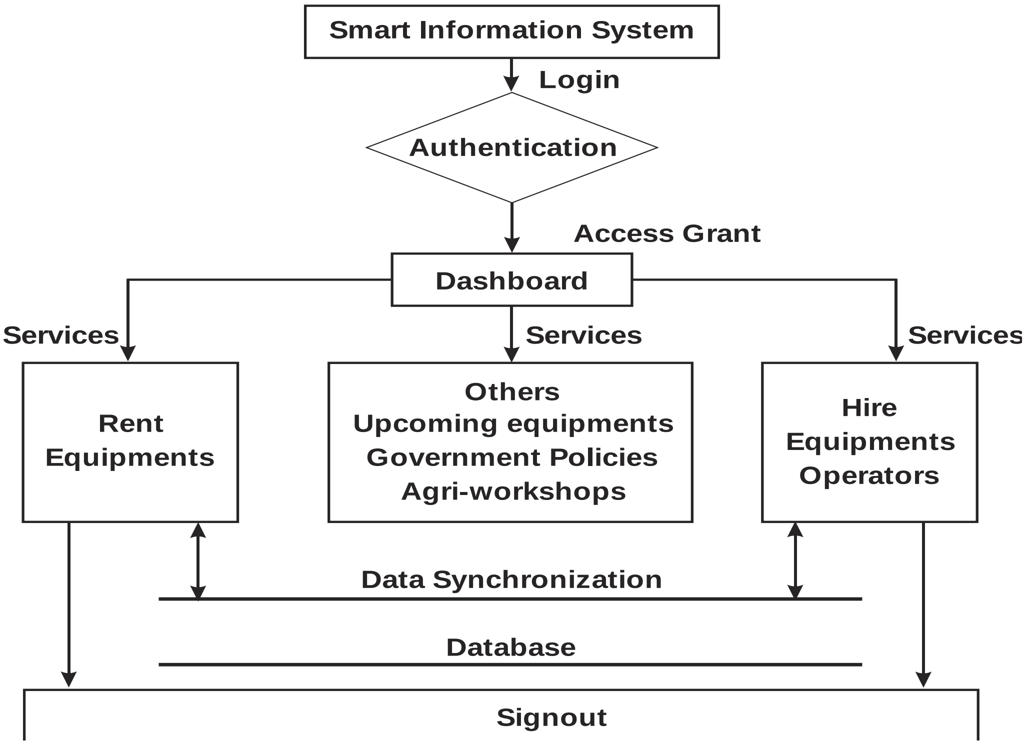


Figure 3.8: Data Flow of Proposed Work

3.5 STEPS BY STEP PROCEDURE: SMARTTILLAGE

About the process, only users who are been authorized by the system admin can rent or Hire their equipment. The user who wants to rent his equipment has to upload the details in the form of equipment image, distance where it can be rented for, cost per day for hiring the machine. Once the data is uploaded by the user, it will be cross checked by the admin of the system and if approved it will be visible in Client and search list. The client has to upload all the properties which the client wants to be listed for hiring or renting. Figure 3.9 depicts layout of the Smart Tillage.

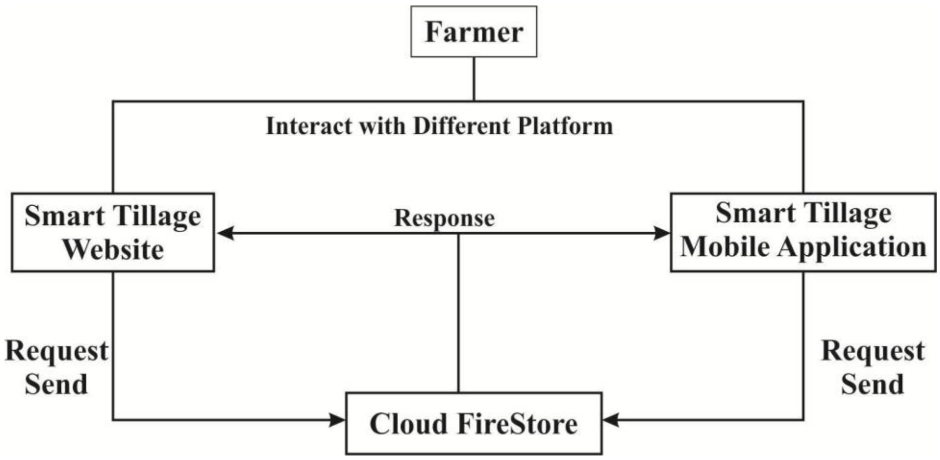


Figure3.9: Layout of Smart Tillage Framework

The client after selecting the location through Google's map longitude and latitude will be able to search for the equipment using filters. From the displayed list client who want to hire the equipment selects the product and click on it, it will popup showing all the details like cost of hiring, available for how many days. If it matches with the requirement of client, he will have to select the hiring dates from the day he wants to hire and till the day it will be hired for. Once the days fixed for hiring the system will display the total rent it will cost. The client then has to send request to the admin for authentication. It will be listed on client dashboard only after the admin approves the request. Along with this, the equipment will be removed from the main search list for other clients for same equipment for same dates. In Fig 3.10, the system is having password based security. Only those users who are having account in this system can access and update details of their own profile only. There are number of parameters used for filtration of date like location, distance, cost per day and number of days. Machine learning is employed to determine the location, pricing information, and number of days the equipment is rented for. search is done via database in order to locate a machine matching the specifications set by the customers. The cost per day is fixed, which will be invoiced after computing the cost for the number of days specified using the calendar function to and from filters. The model was built using machine learning for data analysis and report production.

Figure 3.10 illustrates the client registration process step by step, demonstrating how a client submits a proposal in the form of an image, which requires admin approval before the client can login and view the image. The image will only be available if admin approves it after going through the above-mentioned procedures.

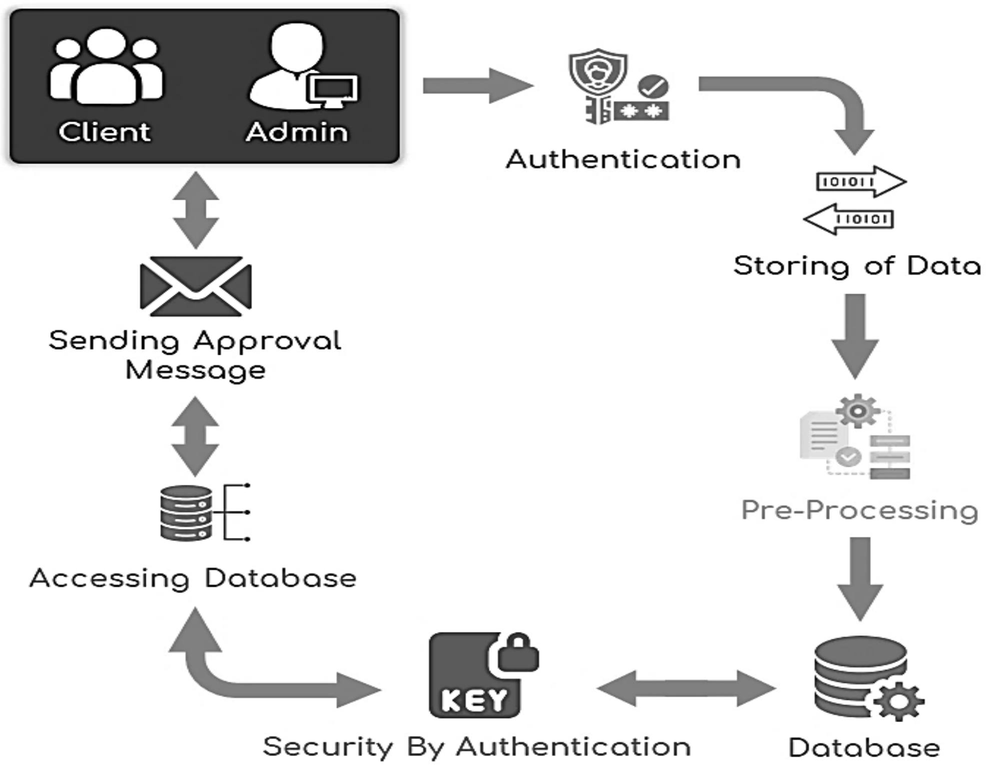


Figure 3.10 : Flow Chart of Proposed Approach

Table 3.2: Methodology/ Tools/ Instruments to be Used

Objective	Sample size (Number of participants)	Instrument/ Tool/ sample design etc. to be used
1	562	Primary data collection, Google form
2	Smart Tillage framework	• HTML Language • CSS Language • Django framework • Python 3.7 • Machine Learning
3	Smart tillage Mobile Application	

3.6 CLIENT APPROACH

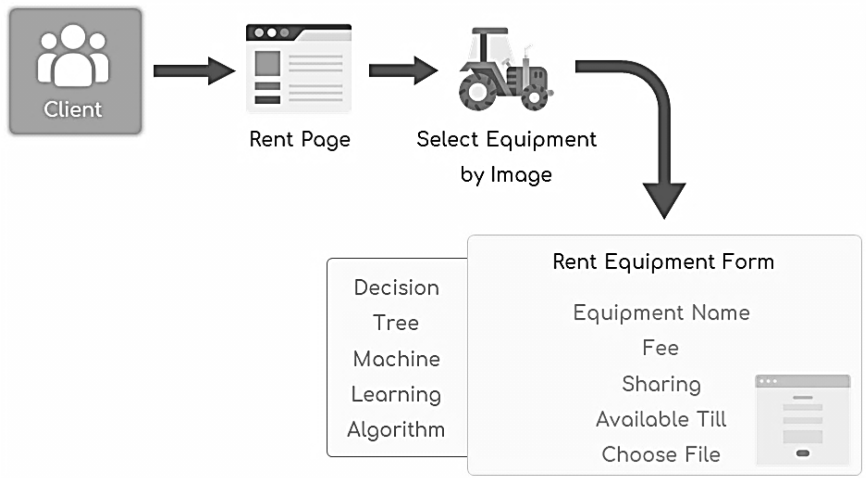


Figure 3.11: Systematic Approach for Renting Equipment

Figure 3.11 represents the systematic approach for renting equipment .The client here can rent and hire the equipment. The client once get registered will upload the equipment details using name, dates for displaying in search list, cost per day and image of product. Once the details are filled the request will be submitted. When it gets approved by the admin, the product will be shown on client dashboard and a message will be received by the client.

3.7 LOCATION PREDICTION APPROACH

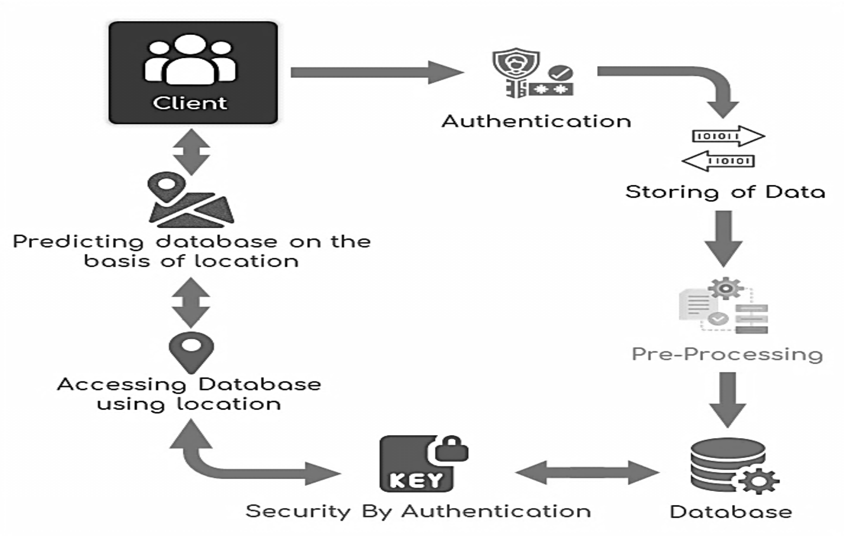


Figure 3.12: Location Prediction Approach

This is the step where the system identifies the location using google map's longitude and latitude clicked by the users logged in to the system, searches the locations within the range selected by the user and display the list of result. Figure 3.12 depicts the location prediction approach used in the system. We have incorporated the Google Astro Library and Open Layer Map, which reveals the current location of the user.

3.8 DISTANCE & COST PREDICATION APPROACH

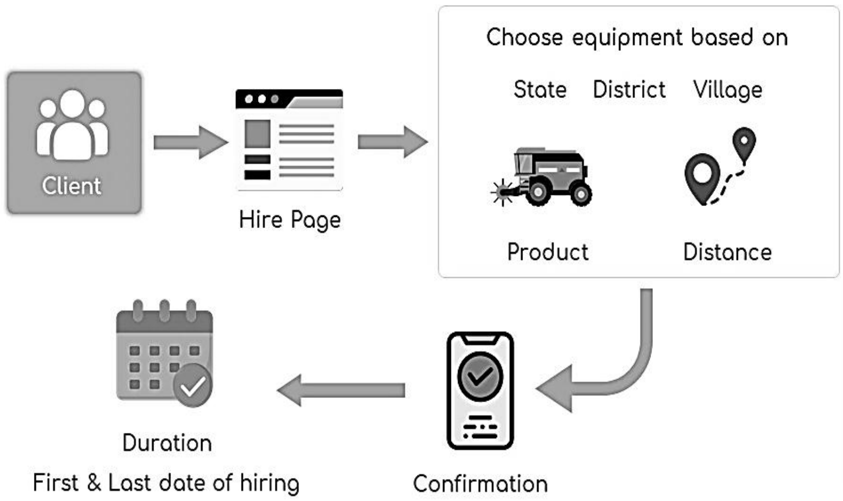


Figure 3.13: Distance and Cost Approach

The distance here is used for search and distance of client who is hiring the rented equipment. It will allow client to have a cost variation which depends on the distance from where the equipment is hired. Normally distance parameter is used to display all the clients who are offering the required product. Figure 3.13 predicts the distance and cost approach. To utilize the equipment; one must search the tool by product name, price, month, and location. Caching will occur if he is in exploring module. The user will be recommended by the product via a content-based recommendation system. When the user goes to the booking module, he will get his first and final hiring dates. The Total cost includes the equipment cost and the travelling cost.

The emphasis of the study was on specific aspects of the proposed method. That the very first step is to collect information, and the second is to incorporate it into the process. The technical points on the first section of the report, which detailed the characteristics of 562 farmers from various Punjab regions, as well as their interpretation based on various categories. The information gathered from actual farmers has been organized.

The whole application would allow the development of a method for determining farmer expectations and demands for resource sharing and the rental of agricultural equipment and machinery. The steps for building a knowledge network that combines artificial intelligence and machine learning in a standardized manner.

3.9 SMART TILLAGE: MOBILE APPLICATION

In the current study with the creation of decision support system we have also designed a smart mobile application called smart tillage from where the user can simply rent and share the Equipment's. Mobile application is the third objective of our current investigation. The systematic scheme of this application is provided in the figure 3.14.

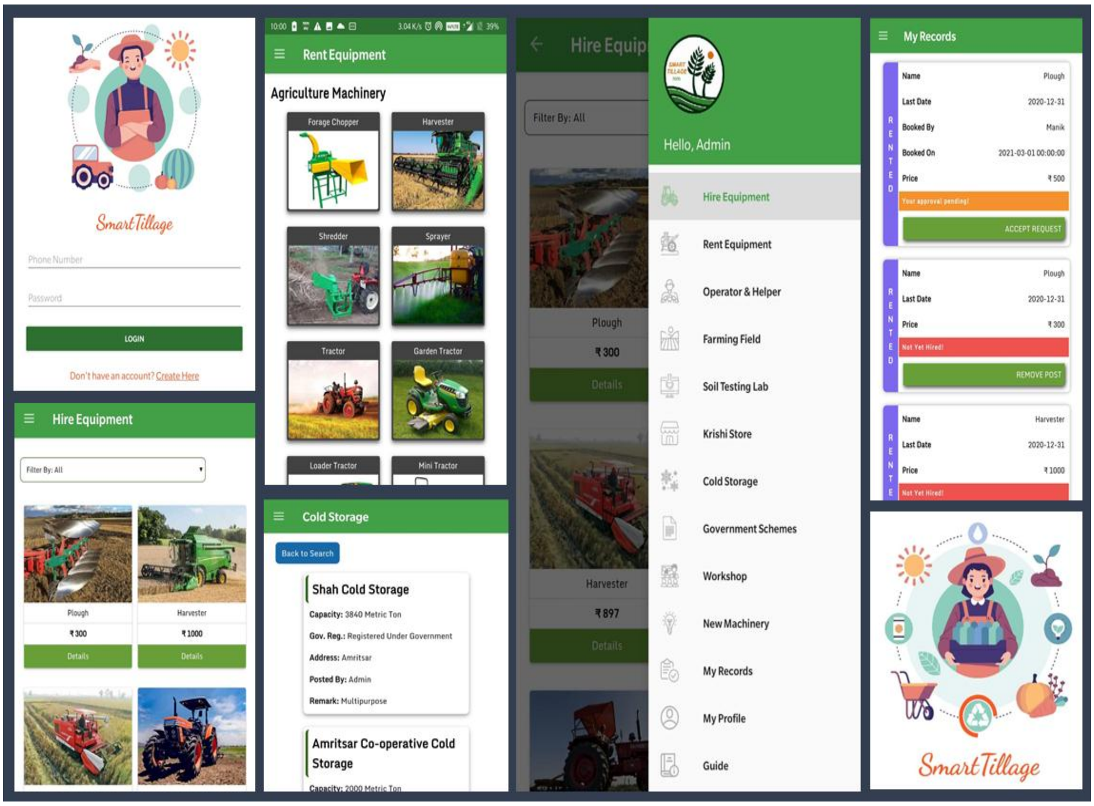


Figure 3.14: Snapshot of Mobile Application

In this recent research, the key objective is to sensitize the farmers towards agricultural mechanization. The major purpose of this activity is to generate awareness among the farmers about the smart tools and equipment's and to encourage renting and sharing. This rental and sharing would further aid the farmers to acquire the essential equipment at the peak season. For this we have Designed, created an Internet based mobile application for the various types of end-users which can be used to market, reserve, rent and share agricultural equipment. With this Mobile application farmers will acquire the proper equipment at the appropriate time. This application consists of many modules.

Module 1

The first module used is to sign up into the system. Figure 3.15 focus on how user Login & Sign up with Web and Application.

Various parameters taken to make a sign up into the proposed system is shown in figure 3.16.

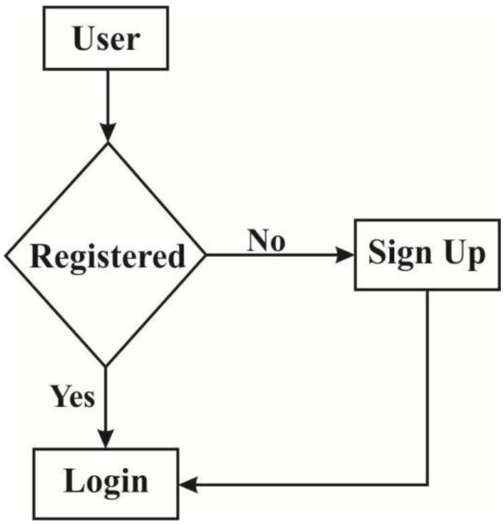


Figure 3.15: User's First Interface – Login & Sign up with Web and Application

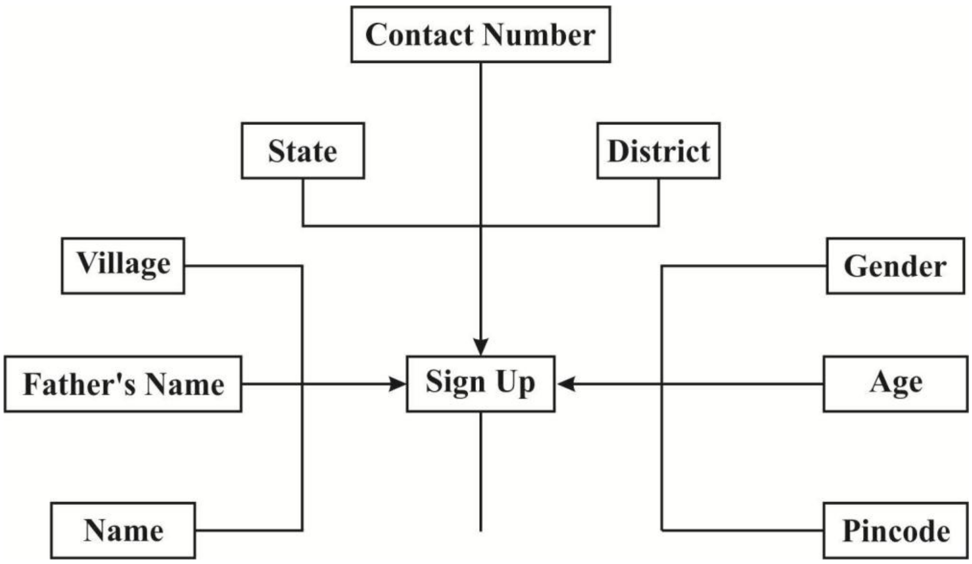


Figure 3.16: Basic Details of the Users

Module 2:-

The second module after sign up will be dashboard that comprises of Renting /hiring of Equipment's. Figure 3.17 predicts the dashboard schema.

Rent / Hire Option

Login → Dashboard → Rent / Hire Options

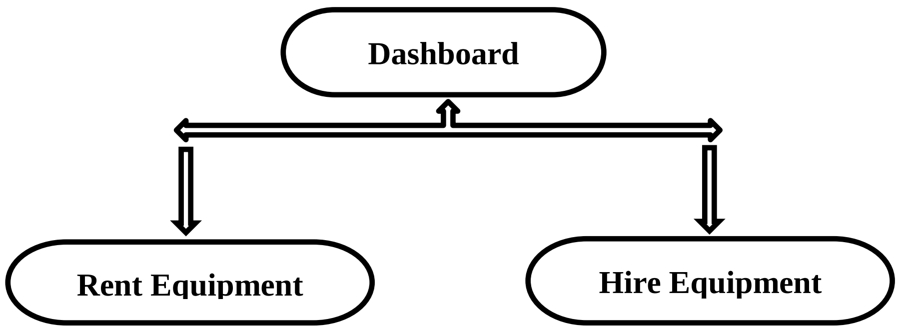


Figure 3.17: Dashboard Schema

Module 3: Renting Module

The Third module will be renting of equipment as shown in figure 3.17. In the renting module the user will click on the required equipment image depending upon the choice of agricultural tool he wants to share. Furthermore it is linked with the rent equipment form which comprises of various parameters like Equipment name, fees (per day basis only), sharing distance, Last date of availability, image of the equipment and description of the equipment.

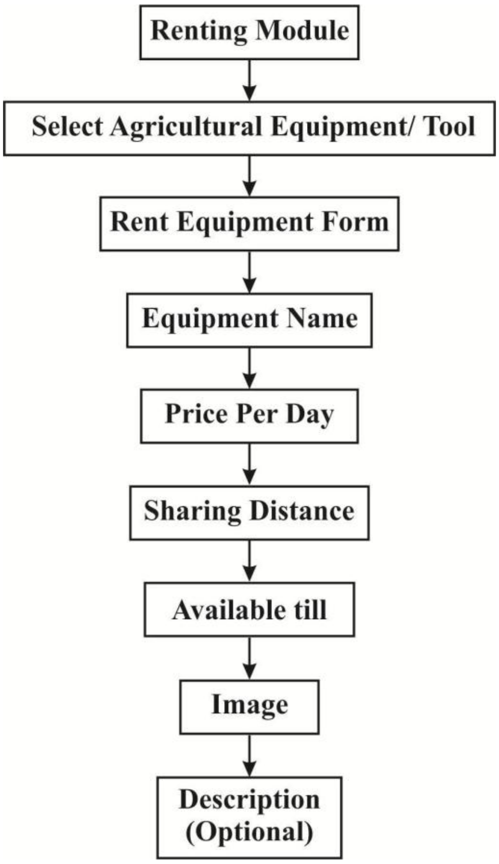


Figure 3.18: Renting Module

Module 4 : Admin Module

The fourth Module in the present study is of admin that is used to approve the request posted by the user who wants to rent his Equipment as shown in figure 3.18.

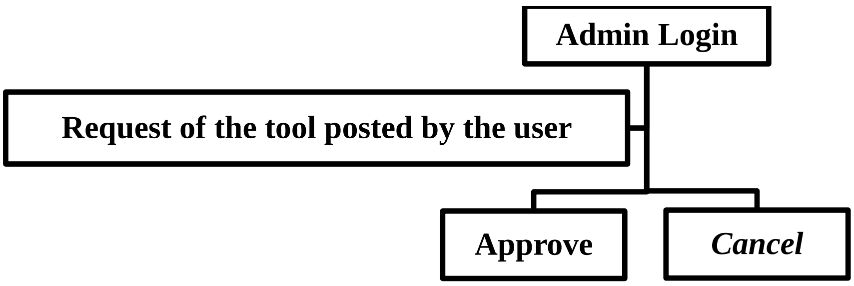


Figure 3.19: Admin Page

Module 5: Hiring Module

Once the request is authorized, the equipment is made accessible in the interface. Prior to booking the equipment, the user is provided with the following information: Equipment Name, Price, Address, Available Till, and the name of the person who rented the tool. Figure 3.20 shows the hiring Module in which we have incorporated the machine learning model and location based prediction approach that predict the rent of the equipment with the transportation cost.

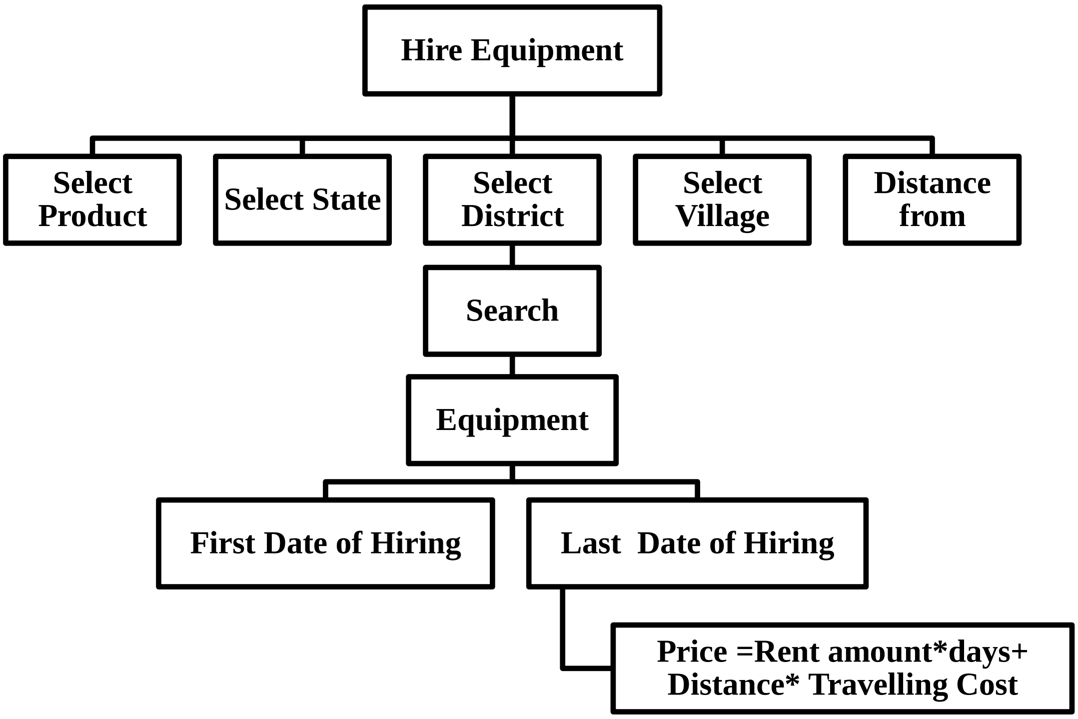


Figure 3.20 : Hiring Module

Module 6:-Searching Module

The mobile application will be linked with the system we've designed, which incorporates machine learning algorithms, as well as location-based algorithms. Those who wish to rent the equipment will sign up in the system. After that, he will be accessible through the option My current location. After clicking "My Location," the current coordinates are collected through GPS, Wi-Fi, or GPRS, and the location is shown on Google Maps with an icon.Figure3.20 shows the process how to locate the user location on map.

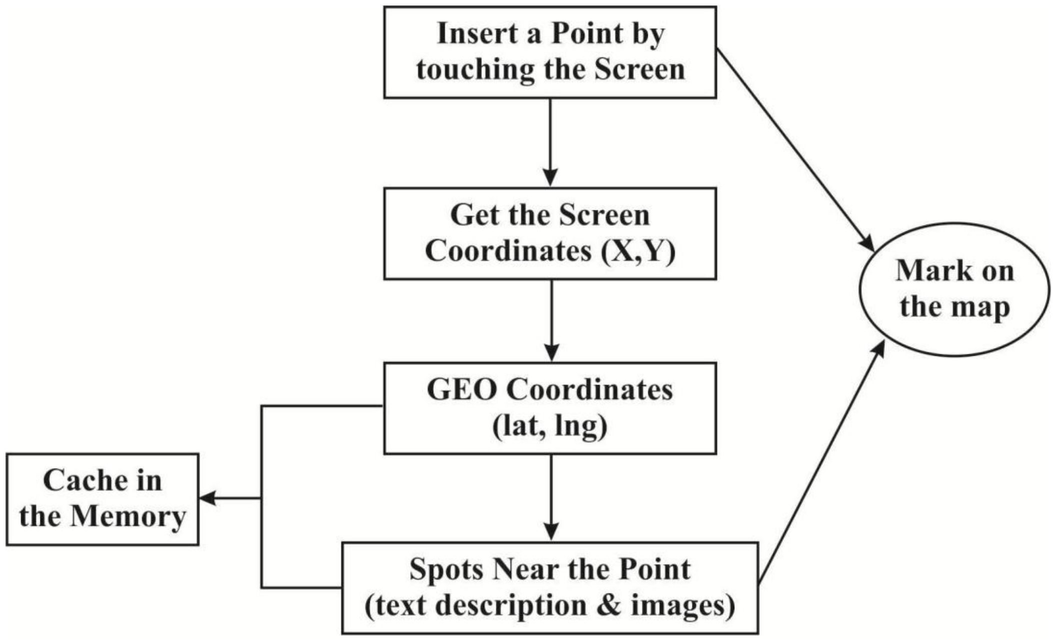


Figure 3.21: User Location on a Google Map

3.10 SUMMARY

This chapter proposes an intelligent decision support system that includes developing an internet-based framework for smart agricultural resource sharing. To achieve the first objective, we surveyed and gathered data from 562 farmers in the Malwa, Majha, and Doaba districts of Punjab. Our predictions indicate that rental and sharing of equipment will be in great demand. Decision tree classifier, a technique in Machine learning, was used to build a system in which users must register before renting or hiring any equipment to accomplish the second objective. We developed the idea of a Recommendation Engine for Optimized Search based on the price, the product's name, the month, and the location. In the recommendation system, we incorporated the concept of content-based filtering and collaborative-based filtering. Furthermore, we discussed the supply-demand-based optimization (SDO) approach in-depth, a novel meta-heuristic optimization technique. SDO is a design for a swarm-based optimizer. In this optimizer, we integrated the concept of active demand forecasting and short-term projections. To achieve the third objective, we developed an Internet-based mobile application that allows end-users to advertise, reserve, rent, and share agricultural equipment.

Chapter – 4

RESULTS AND DISCUSSION

This chapter includes the results and discussion of Internet based Smart Agriculture Resource Sharing Framework. Herein, the data collection of 562 farmers has been done and after that this collected data was analysed. For the valuable analysis of data a smart information system is developed which can be further used for the technological solution to promote farm equipment renting and sharing. The collected samples were analyzed by machine learning algorithms. Three machine learning classifiers are used for the analysis: logistic regression, k Neibors classifiers, and a decision tree. The selected classifiers are used to predict the best accuracy. This chapter includes the result that indicates how many farmers would want to use our technology. Herein; we integrated the demand supply algorithm to estimate how the price fluctuation would be in the market. To make the predictions, many variables were collected from the dataset. On the basis of these collected data an internet based Mobile application is launched which can be further used to advertise, reserve, rent and share agricultural equipment's.

The proposed work is carried out for the improvement in the field of agriculture basically in Punjab. In the field of agriculture the rate of Punjab is falling very vastly. The reason behind this is discussed under the following heads:

- Fluctuation in the farming is based on the number of parameters that are mainly responsible for the farmers which includes educational qualification, age, annual income, expenditure, number of family members, lack of technical knowledge, under the burden of loans, which tools they are having, what is the reason of loans and many more.
- These above mentioned problems are responsible for the downfall of farming in Punjab. In order to consider this, a socio-economic level survey has been conducted

and the usage of a technological solution has been done to promote farm equipment renting and sharing.

- To design, develop and launch an internet based mobile application for the various types of end-users which can be used to advertise, reserve, rent and share of agriculture equipment.
- Analysis of these collected data has been illustrated by varying different parameters.

To achieve first objective, collection of data has been discussed under section 3.1. Herein various parameters have been recorded. These parameters include number of sections which are responsible to find the causes and effects of the farmers while farming. This survey data has been collected manually and for this collection of data a questionnaire has been prepared. This questionnaire includes all the basic information of the farmers which will help to reach up to the point that why the farmers in the Punjab are committing suicide. Section 3.2 deals with the effect of one parameter towards others. The analysis of these effected parameters has been discussed. After the analysis, we have used various Machine learning algorithm. Different classifiers like Decision tree, K-Neighbour and linear regression are used to predict the accuracy of the model. A framework named Smart-Tillage is developed.Smart-Tillage is a platform where user has to register before they get permitted to rent or hire any equipment through this application, which has been developed using machine learning for the data-manipulating and designed in Django 13.2 for front-end and Database used is the latest technique i.e Postgre SQL for better security and data processing. Additionally, we've applied the demand-supply algorithm to anticipate the fluctuation in the peak season. In the training set, 70% of the data is chosen for usage while the remaining 30% is utilized as a test dataset, showing that demand and supply are inversely related to each other.

With the use of this algorithmic system we reached up to the point that renting and sharing is the basic problem of Punjab farmers. Till now Punjab is coming under the series of developing states. In order to view this we reached up to the point that this problem can be resolved. Section 3.3 describes third objective of this present study that a mobile App has been developed and launched which will assist the farmers in renting and sharing of the Equipment.

Basic Data

Section 3.1 includes the collection of data of 562 farmers.. Some of the samples are included in the figure 3.1. It has found that there are different crisis faced by the farmers. In order to view the cause of these crisis, this present study look into the questionnaire in which questions has been asked to the farmers to figure out the various issues faced by the farmers. These questions are enlisted below :-

- To which category they belong (a) small (b) medium (c) Large.
- How much land they acquire?
- What is their annual income and what is their Monthly Expense?
- What kind of farming they are doing and what kind of crop they sow?
- Have they availed loan and what is the purpose of loan?
- What type of equipment they are having?
- Do they need an operator?
- Up to how far they are prepared to share the equipment?
- What is their annual income from agriculture?
- Do they find difficulty in finding machinery in harvesting seasons?
- Would they like to rent the equipment?
- Do you have a Smartphone?

Table 4.1 just represents the dummy data set of collected data. The questionnaire is also attached in the Annexure.

Table 4.1: Snap Short of Collected Data just a Kind of Sample.

1	2	3	4	5	6	7	8	9	10	11	12
NAME	***VILLAGE***	***LAND***	***AGE***	***GENDER***	***EDUCATION***	***FAMILY MEMBERS***	***PER MONTH EXPENSE***	***AGRI EXPERIENCE***	***FARMER CATEGORY***	***FARM REGISTERED OR NOT***	***AWARE OF NEW FARMING TOOLS***
BUTA SINGH	*BANGER MUHABAT SINGH BATHINDA*	*3 ACRES*	*38*	*MALE*	*GRADUATE*	*4*	*10000-25000*	*18*	*SMALL*	*NO*	*YES*
GURDEV SINGH	*BANGER MUHABAT SINGH BATHINDA*	*1 ACRES*	*40*	*MALE*	*SECONDARY*	*4*	*10000-25000*	*20*	*SMALL*	*NO*	*NO*
GURJANT SINGH	*BANGER MUHABAT SINGH BATHINDA*	*2 ACRES*	*39*	*MALE*	*SECONDARY*	*6*	*25000-50000*	*19*	*SMALL*	*NO*	*NO*
MAHINDER SINGH	*BANGER MUHABAT SINGH BATHINDA*	*3 ACRES*	*44*	*MALE*	*SECONDARY*	*5*	*25000-50000*	*24*	*SMALL*	*NO*	*YES*
MEJOR SINGH	*BANGER MUHABAT SINGH BATHINDA*	*3 ACRES*	*48*	*MALE*	*SECONDARY*	*6*	*25000-50000*	*28*	*SMALL*	*NO*	*YES*
PARMINDER SINGH	*BANGER MUHABAT SINGH BATHINDA*	*6 ACRES*	*55*	*MALE*	*SECONDARY*	*5*	*25000-50000*	*35*	*MEDIUM*	*NO*	*YES*

1	2	3	4	5	6	7	8	9	10	11	12
NAME	***VILLAGE***	***LAND***	***AGE***	***GENDER***	***EDUCATION***	***FAMILY MEMBERS***	***PER MONTH EXPENSE***	***AGRI EXPERIENCE***	***FARMER CATEGORY***	***FARM REGISTERED OR NOT***	***AWARE OF NEW FARMING TOOLS***
GURTEK SINGH	*BANGER MUHABAT SINGH BATHINDA*	*5 ACRES*	*60*	*MALE*	*GRADUATE*	*5*	*25000-50000*	*40*	*MEDIUM*	*NO*	*YES*
RAJINDER SINGH	*BANGER MUHABAT SINGH BATHINDA*	*5 ACRES*	*39*	*MALE*	*SECONDARY*	*4*	*10000-25000*	*19*	*MEDIUM*	*NO*	*YES*
PARAMPAL SINGH	*BANGER MUHABAT SINGH BATHINDA*	*7 ACRES*	*52*	*MALE*	*SECONDARY*	*4*	*10000-25000*	*32*	*MEDIUM*	*YES*	*YES*
GOBIND SINGH	*BANGER MUHABAT SINGH BATHINDA*	*3 ACRES*	*54*	*MALE*	*SECONDARY*	*5*	*25000-50000*	*34*	*SMALL*	*NO*	*YES*
BANTA SINGH	*BANGER MUHABAT SINGH BATHINDA*	*5 ACRES*	*39*	*MALE*	*SECONDARY*	*4*	*10000-25000*	*19*	*MEDIUM*	*NO*	*YES*
HARBANS SINGH	*BANGER MUHABAT SINGH BATHINDA*	*6 ACRES*	*52*	*MALE*	*GRADUATE*	*6*	*25000-50000*	*32*	*MEDIUM*	*NO*	*YES*
PARGAT SINGH	*BANGER MUHABAT SINGH BATHINDA*	*4 ACRES*	*50*	*MALE*	*GRADUATE*	*3*	*10000-25000*	*30*	*SMALL*	*NO*	*YES*

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
TYPE OF FARMING	**CROPS**	**AVAILED LOAN OR NOT**	**UNDERGONE TRANING**	**OWN TOOLS**	**REASON OF LOAN**	**DO YOU NEED OPERATOR**	**CONSIDERABLE DISTANCE WHILE LENDING MACHINERY (UP TO)**	**INCOME FROM AGRICULTURE**	**LOAN SOURCE**	**NEED OF COLD STORAGE**	**WOULD YOU LIKE TO HIRE MACHINERY**	**DO YOU FIND IT DIFFICULT TO FIND MACHINERY IN HARVESTING TIME**	**DO YOU ATTEND AGRICULTURE TRAINING WORKSHOPS**	**INTERESTED IN APP FOR CUSTOM HIRING**	**DO YOU UES SMART PHONE?**
TRADITIONAL	WHEAT, MAIZE, RICE, PULSES, SUGARCANE, FRUITS AND VEGETABLES	YES	AGRICULTURE	PLOUGH	PLANTATION, FERTILIZATION	YES	5	50000-200000	COOPERATIVE BANK	NO	YES	YES	YES	YES	NO
TRADITIONAL	WHEAT, MAIZE, RICE, PULSES, SUGARCANE, FRUITS AND VEGETABLES	NO	AGRICULTURE	NO TOOLS	NO LOAN	YES	NO TOOLS	50000-200000	NO LOAN	NO	YES	YES	NO	YES	NO

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
TYPE OF FARMING	**CROPS**	**AVAILED LOAN OR NOT**	**UNDERGONE TRANING**	**OWN TOOLS**	**REASON OF LOAN**	**DO YOU NEED OPERATOR**	**CONSIDERABLE DISTANCE WHILE LENDING MACHINERY (UP TO)**	**INCOME FROM AGRICULTURE**	**LOAN SOURCE**	**NEED OF COLD STORAGE**	**WOULD YOU LIKE TO HIRE MACHINERY**	**DO YOU FIND IT DIFFICULT TO FIND MACHINERY IN HARVESTING TIME**	**DO YOU ATTEND AGRICULTURE TRAINING WORKSHOPS**	**INTERESTED IN APP FOR CUSTOM HIRING**	**DO YOU UES SMART PHONE?**
TRADITIONAL	WHEAT, MAIZE, RICE, PULSES, SUGARCANE, FRUITS AND VEGETABLES	YES	NO	NO TOOLS	PLANTATION, FERTILIZATION	YES	NO TOOLS	50000-200000	COOPERATIVE BANK	NO	YES	YES	NO	YES	NO
TRADITIONAL	WHEAT, MAIZE, RICE, PULSES, SUGARCANE, FRUITS AND VEGETABLES	NO	AGRICULTURE	PLOUGH	NO LOAN	YES	5	50000-200000	NO LOAN	NO	YES	YES	YES	YES	YES

In order to analyze the data the farmers are divided into three category i.e small, medium and large. From the total 562 farmers, 377 famers falls under the category of small farmers, 179 lies in the category of medium and 6 farmers fall in the large farmers category.

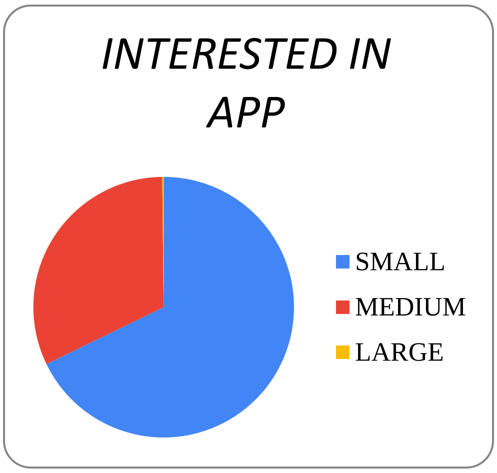
The main issue of the farmers is that they are not sensitized with the modern Equipment and tools and on the flip side they are falling under the burden of debt which forces them to commit suicide. In order to resolve this concern of the farmers, we have developed a uberized model which deals with the renting and sharing of farming Equipment. So in order to run this uberized model our first concern is to find how many farmers have their own smart phone. Fig. 4.1 represents the out of these collected information - in case of small category out of 377 farmers, 155 farmers have smart phones, out of total 177 medium farmers 144 medium and out of 6 large farmers, 5 large farmers have their smart phones.

Out of these all the small farmer i.e 377 and 178 medium and 1 large farmer are interested in smart phones. The concept of this parameter selection is reached to the view of custom hiring system so that farmers can rent and hire their equipment. accordingly.

4.1 BASIC INFORMATION

Table 4.2 : Farmer Category Interested in Mobile App and Smart Phones.

Analysis of Farmer Category Vs Interested in App			Analysis of Farmer Category Vs Smart Phone Use	
Farmer Category	Interested In App		Farmer Category	Smart Phone Use
Small	377		Small	155
Medium	178		Medium	144
Large	1		Large	5



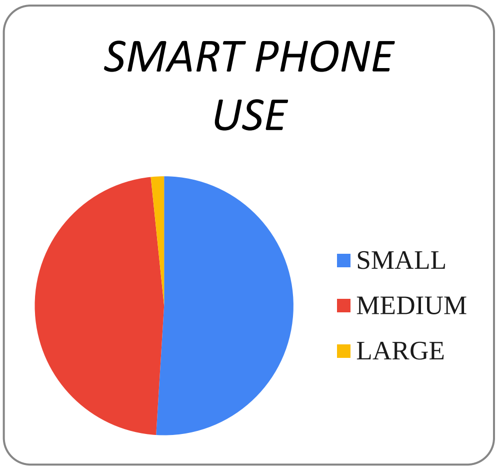


Fig. 4.1 : Analysis of Farmer Category V/S Interested in Mobile App.

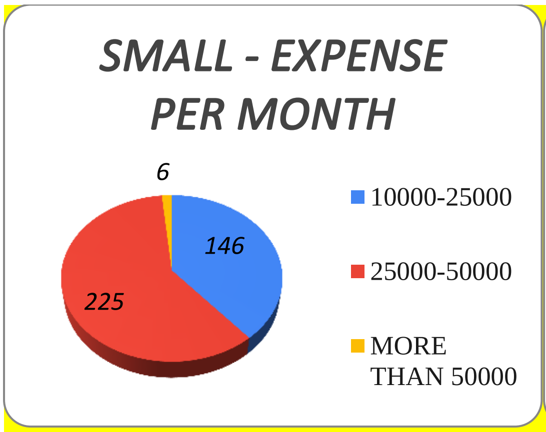
4.2 FARMERS CATEGORY WITH EXPENSES AND THEIR INCOME

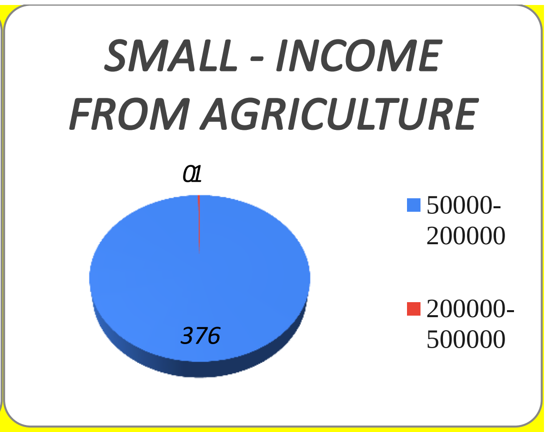
Table 4.3 : Farmers Category with per Month Expenses and Income from Agriculture.

Farmer Category	Per Month Expense	Count of Farmers	Income from Agriculture	Count of Farmers
Small	10000-25000	146	50000-200000	376
	25000-50000	225	200000-500000	1
	More Than 50000	6	More Than 500000	0
Medium	10000-25000	56	50000-200000	19
	25000-50000	120	200000-500000	159
	More Than 50000	3	More Than 500000	1
Large	10000-25000	3	50000-200000	1
	25000-50000	3	200000-500000	0
	More Than 50000	0	More Than 500000	5

Fig. 4.2 depicts the comparison of small, medium and large farmers on the basics of their expenses, count, income from agriculture and count of farmers.

Table 4.3 represents all the category of farmers experienced their per month expenses in the range of 10,000-25,000/-, 25,000-50,000/- and more than 50,000/- These expenses are labelled as A, B and C under the three different category - small, medium and large. For the label A – 146 farmers in the small, 56 in the medium and 3 farmers falls under the category of large farmers. For the label B – 225 falls in the small, 120 in the medium and 3 farmers lies under the large category. Similarly in case of C – 6 in the small, 3 in the medium and no farm lies under the large category. However, the next part of this table represents farmers category with income from agriculture and their number of counts. In order to consider this income from agriculture is categorized into three groups i.e 50,000-2, 00,000/-, 2, 00,000 – 5, 00,000/- and more than 5, 00,000/-. This income from the agriculture is labelled as D, E and F. In case of label D – 377, 19 and 1 farmers lies in the small, medium and large category. For the label E – 1, 159 and no farmers fall in the small, medium and large category. For the label F – 0,1 and 5 farmers in the region of small, medium and large category.





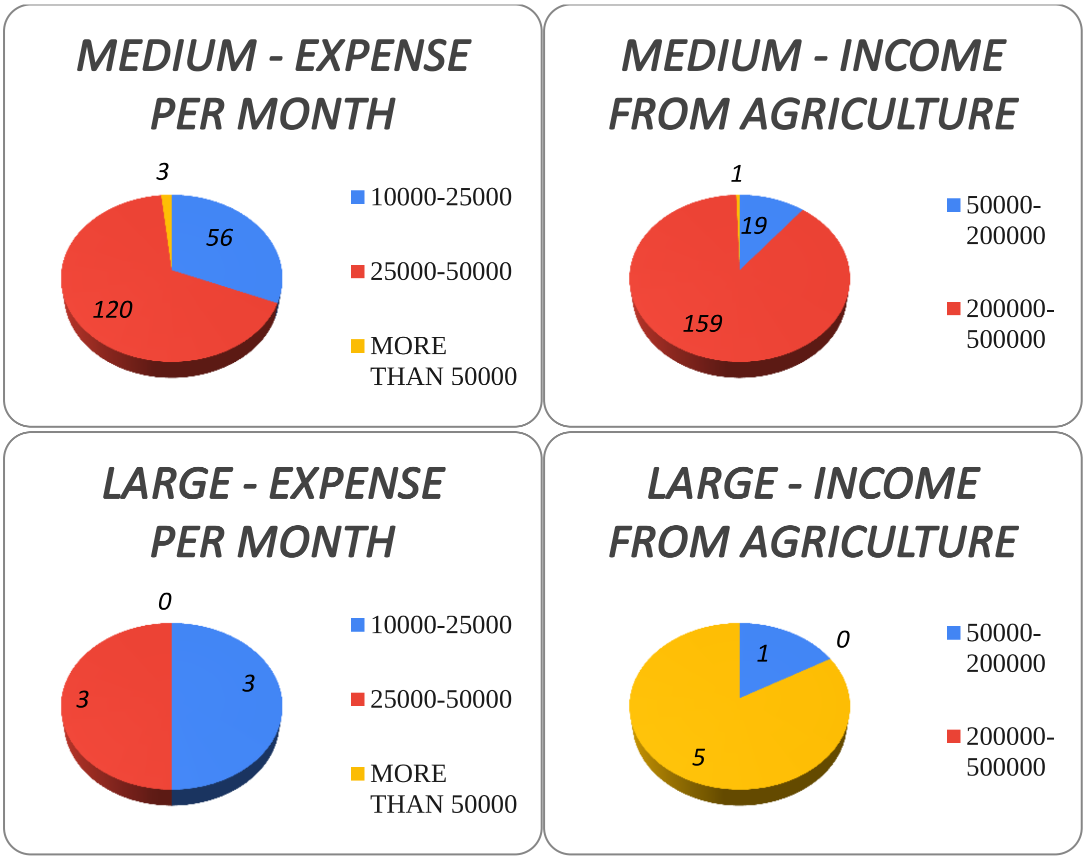


Fig. 4.2 : Farmers Category v/s Expenses per Month and Income from Agriculture.

4.3 ANALYSIS BETWEEN FARMER CATEGORY, REASON OF LOAN AND THEIR WISH TO HIRE MACHINERY

Table 4.4 depicts based on the three categories of the farmers: small, medium and large. Out of these all categories some of the farmers are interested in loan while others are not. Loan is one of the main causes that force the farmers to commit suicide. From this mentioned analysis this inference depicts that the maximum farmers from different categories have taken loan to buy new machinery. This survey reached to the result that farmers are under the burden of loans due to following reasons

- ❖ Plantation and Fertilization
- ❖ New Machinery
- ❖ Land Development
- ❖ Education

Table 4.4 : Analysis between Farmer Category and they availed Loan or not with Reason and their wish to Hire Machinery.

FARMER CATEGORY	AVAILED LOAN OR NOT	REASON OF LOAN	COUNT OF REASON	WOULD YOU LIKE TO HIRE MACHINERY
SMALL = 377	YES = 179	PLANTATION, FERTILIZATION	10	179
		NEW MACHINERY	127	
		LAND DEVELOPMENT	42	
		EDUCATION	0	
	NO = 198	NOT AVAILED LOAN	198	197
MEDIUM = 179	YES = 53	PLANTATION, FERTILIZATION	0	51
		NEW MACHINERY	28	
		LAND DEVELOPMENT	25	
		EDUCATION	0	
	NO = 126	NOT AVAILED LOAN	126	121
LARGE = 6	YES = 4	PLANTATION, FERTILIZATION	0	2
		NEW MACHINERY	4	
		LAND DEVELOPMENT	0	
		EDUCATION	0	
	NO = 2	NOT AVAILED LOAN	2	2

Figure 4.3 represents that out of 377 small farmers, 179 are interested in loan and 198 are not interested in loan and all 179 are interested in hiring machinery. In the medium category, out of 179 farmers, 53 are availing loan and all are interested in custom hiring, others 126 are not interested in loans, 121 are interested in hiring

machinery. From the large farmer category, out of 6, 4 farmers are interested in loan and all are interested in hiring machinery and other 2 are not want to avail the loan but they are interested in hiring machinery. Fig. 4.3 also depicts the reason of loan for the farmers. This analysis reached up to the mark that this is the reason due to which farmers are under the suicide.

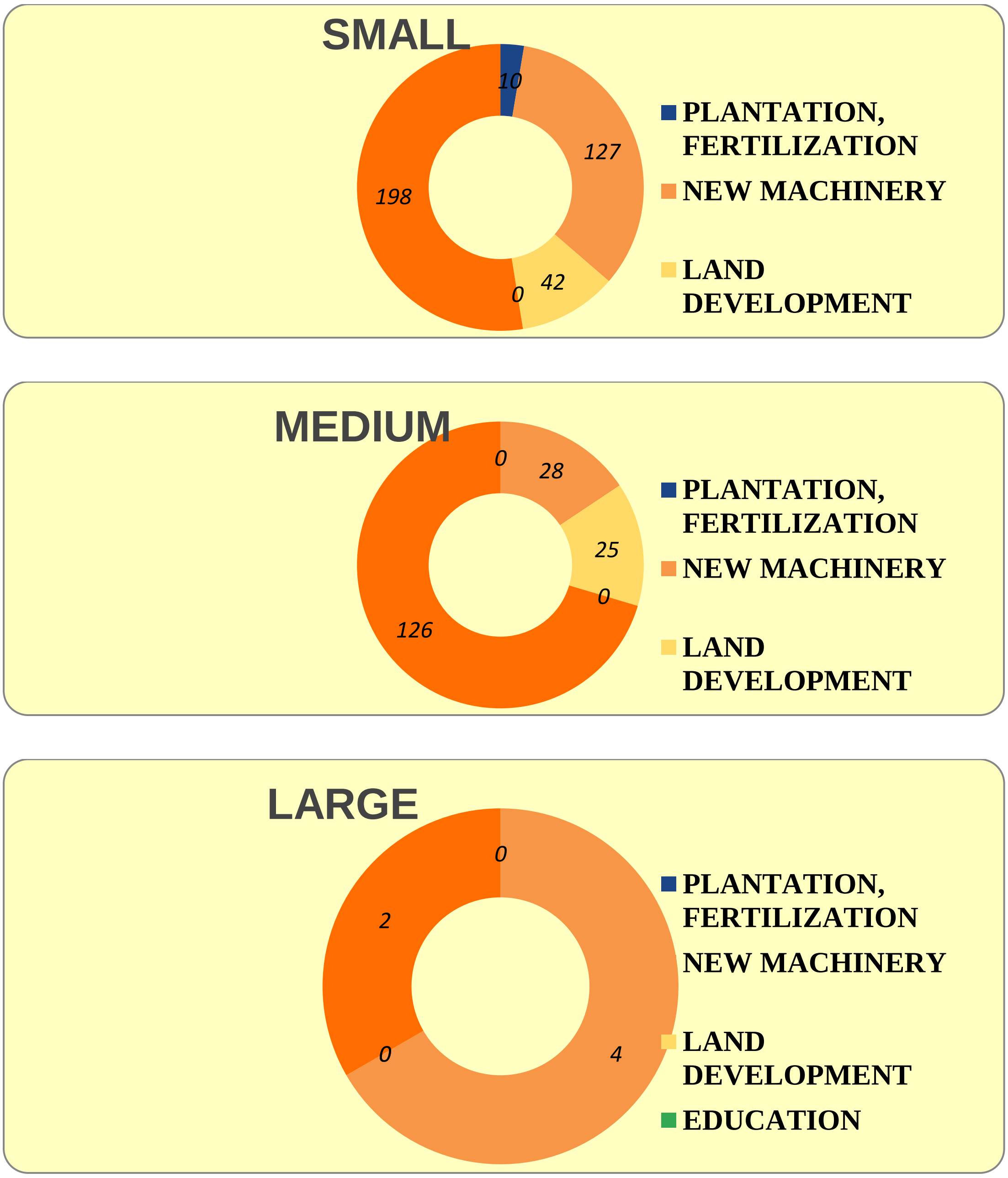


Fig. 4.3 : Relationship between Farmer Category and their Reason and Wish to Hire Machinery.

Table 4.5 : Category wise Education and their Interest to Hire the Machinery.

EDUCATION	FARMER CATEGORY	COUNT OF FARMER CATEGORY	WOULD YOU LIKE TO HIRE MACHINERY	INTERESTED IN APP FOR CUSTOM HIRING
	SMALL	41	41	41
ILLITERATE	MEDIUM	16	14	15
	LARGE	0	0	0
EDUCATION	FARMER CATEGORY	COUNT OF FARMER CATEGORY	WOULD YOU LIKE TO HIRE MACHINERY	INTERESTED IN APP FOR CUSTOM HIRING
	SMALL	187	187	187
SECONDARY	MEDIUM	122	118	122
	LARGE	1	0	0
EDUCATION	FARMER CATEGORY	COUNT OF FARMER CATEGORY	WOULD YOU LIKE TO HIRE MACHINERY	INTERESTED IN APP FOR CUSTOM HIRING
	SMALL	149	148	149
GRADUATE	MEDIUM	41	40	41
	LARGE	5	4	1

4.4 COMPARISON OF THE FARMER CATEGORY WITH EDUCATION, HIRE MACHINERY AND INTERESTED IN MOBILE APPLICATION

In order to develop the mobile application, first of all we have to find the education level of the farmers i.e how much of them are illiterate, secondary and graduate. Fig. 4.4 represents percentage of farmers according to their category such as small, medium and large. In case of illiterate 72% falls in the small, 28% in the medium and no one fall in the large category. In case of secondary education, 60% falls under the small, 40% in the medium and no one falls under the large category. For the graduation level, 76% under the small, 21% in the medium and 3% in the large category.

Herein, in order to view the concept of hire machinery and the interest of farmers in mobile app a comparison has been made with education level. Fig. 4.5 depicts the statistics data which is collected from 562 farmers about their above mentioned parameters which will help the farmers to rent and share their farm equipment.

This figure 4.5 (a) shows the statistics of illiterates. From small farmer category, 41 farmers are found to be illiterates and all 41 of them are willing to hire machinery and are in need to mobile application. In case of medium farmer category, 16 farmers are found to be illiterates, of which, 14 chose to hire machinery and 15 farmers decided to have the mobile application for renting and sharing machinery. When it comes to large farmer category, none of them are illiterates which resulted in neither of them asking to hire machinery and mobile application.

Now coming to the farmers that have secondary education. Figure 4.5 (b) represents that 187 farmers under small farmer category had their secondary education and all of them are interested in hiring machinery and are in need of a mobile application for hiring and sharing machinery. A total of 122 farmers than are falling under medium farmer category and they had their secondary education. All 122 of them are interested in having a mobile application but only 118 of them are actually interested in hiring machinery. Finally, only 1 farmer fall under large farmer category that had their secondary education and that one farmer is not interested in either hiring machinery or in need of a mobile application.

The figure 4.5 (c) depicts the statistics of the farmers that completed their graduation. Herein, 149 farmers are belonging to small farmer' category and all are found to have completed their graduation and are interested in mobile application and out of these, 148 farmers are interested in hiring machinery. 41 of the farmers that fell under medium farmer category completed their graduation. 40 of them are interested in hiring machinery and all 41 of them are in need of a mobile application for hiring and sharing. Finally, 5 of the farmers are felt under large farmer category completed their graduation. 4 of them are interested in hiring machinery and only 1 of them is interested in mobile application. This concluded that all the farmers whether they belong to any category they are interested in the mobile app.

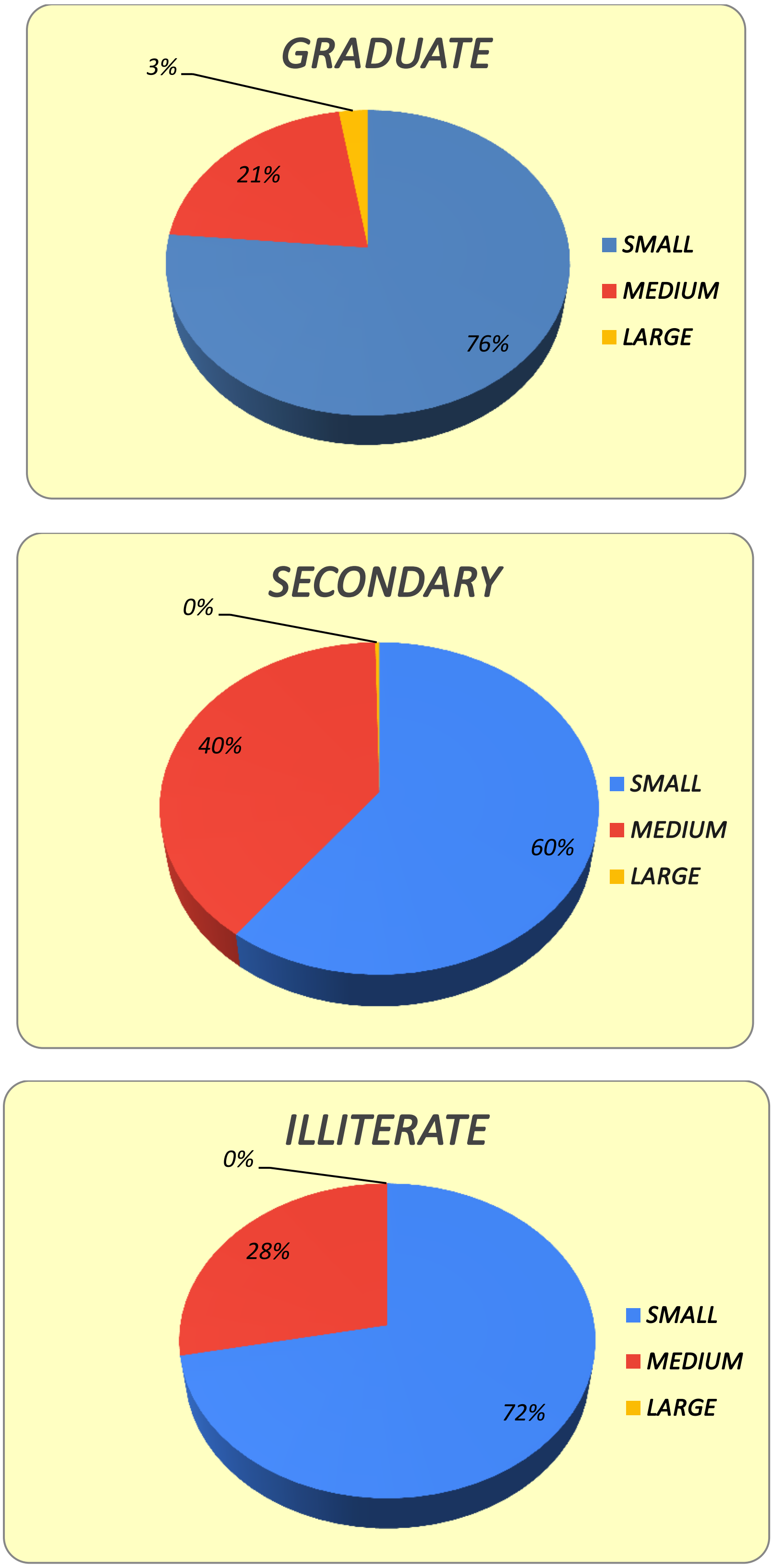
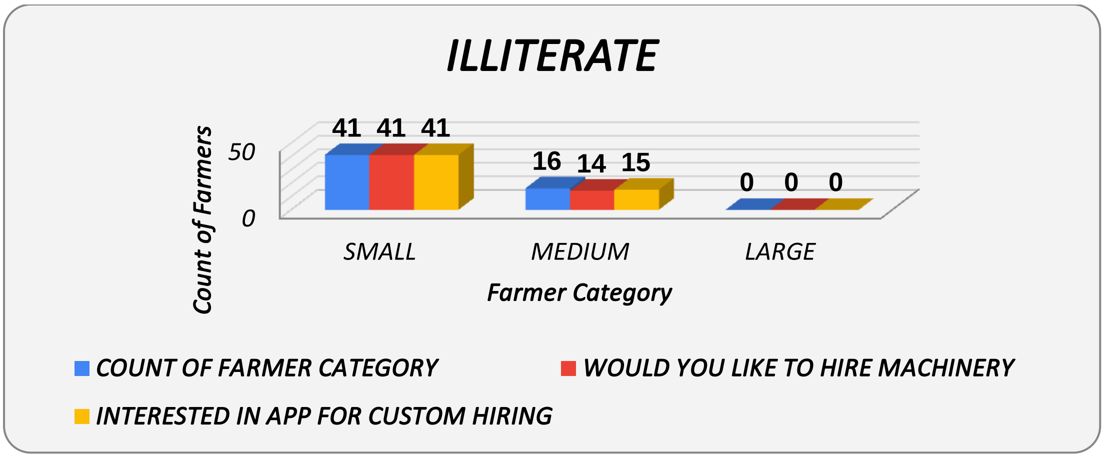
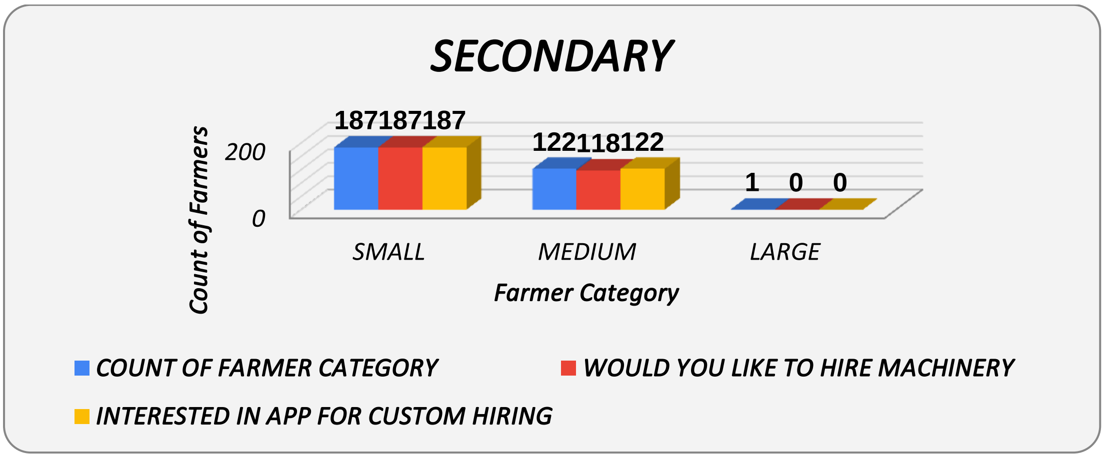


Fig. 4.4 : Percentage of Farmers Education with Small, Medium and Large Category.





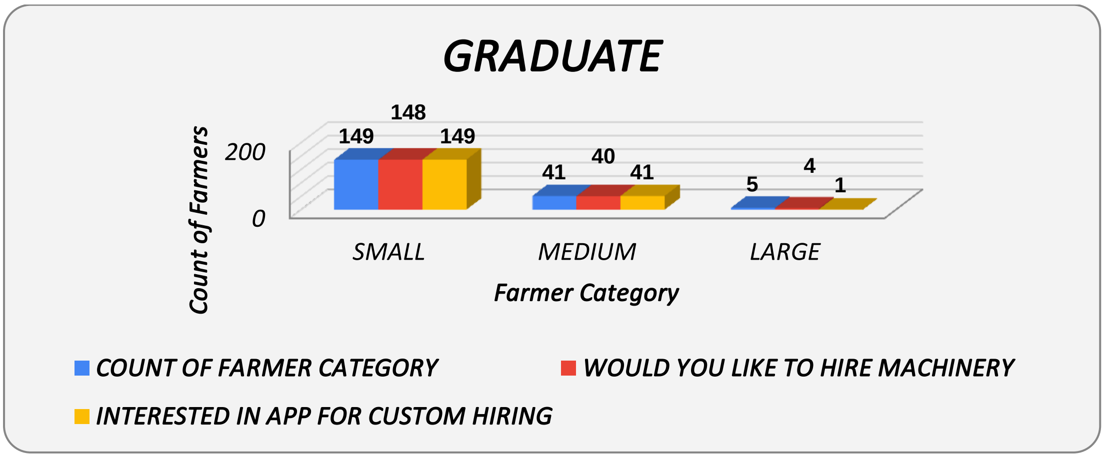


Fig. 4.5 : Farmers interested in Hiring Machinery and Mobile Application at the different Education Level.

4.5 ANALYSIS OF DISTANCE UP TO WHICH DIFFERENT CATEGORIES OF FARMERS ARE WILLING IN SHARING THEIR TOOLS/EQUIPMENT.

To link with the above mentioned analysis the next parameter focused on for how much distance farmers are willing in sharing their tools. This sharing of tools will be further helpful for those farmers who are unable to buy farming equipment. In this recent research, our main focus was in the renting and sharing of farming equipment so in order to view this developed questionnaire includes this question too i.e considerable distance while landing machinery. This table describes different category of the farmers with different attributes such as they do not having any tool or they can share their tool up to 3 Km, 5 Km, 10 Km and more than 10 Km. From this conducted survey in different district with various villages we analysed that the farmers are willing to share and rent the equipment. This analysis describes the farm category: small, medium and large. Table 4.6 depicts that how many farmers are willing for how much distance for renting and sharing of equipment. Fig. 4.6 also describes the count of farmers for sharing of their tools.

Table 4.6 : Category wise Considerable Distance While Lending Machinery

FARMER CATEGORY	CONSIDERABLE DISTANCE WHILE LENDING MACHINERY (UP TO)	COUNT OF FARMERS
		Small
SMALL	NO TOOLS	179
	3 KM	10
	5 KM	89
	10 KM	99
	MORE THAN 10	0

FARMER CATEGORY	CONSIDERABLE DISTANCE WHILE LENDING MACHINERY (UP TO)	COUNT OF FARMERS
MEDIUM		**Medium**
	NO TOOLS	0
	3 KM	5
	5 KM	86
	10 KM	86
	MORE THAN 10	2
LARGE		**Large**
	NO TOOLS	0
	3 KM	0
	5 KM	2
	10 KM	4
	MORE THAN 10	0

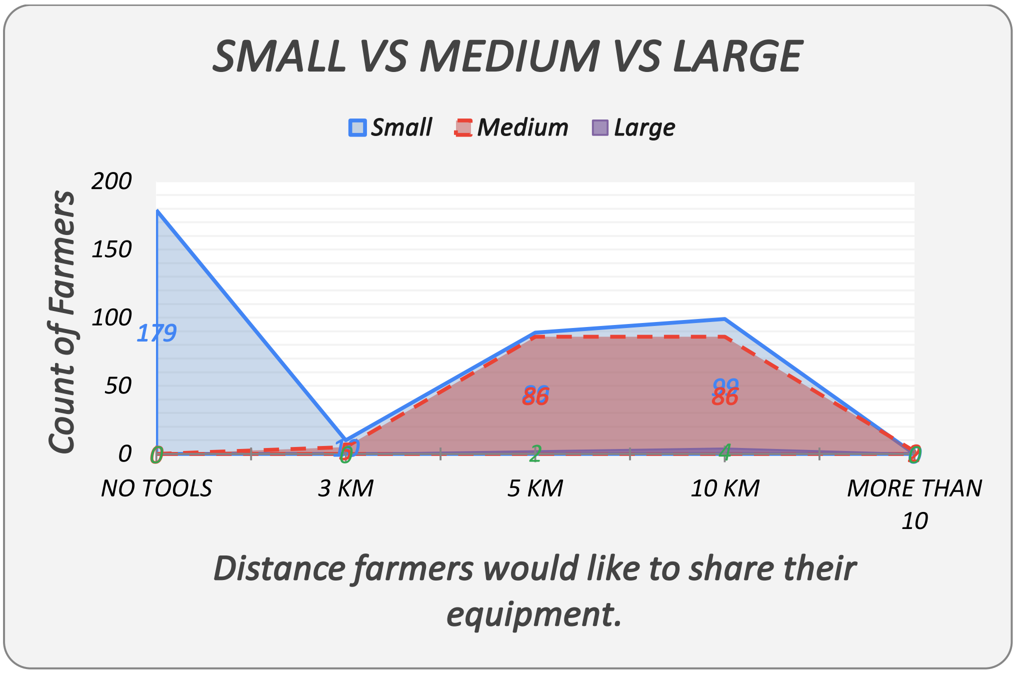


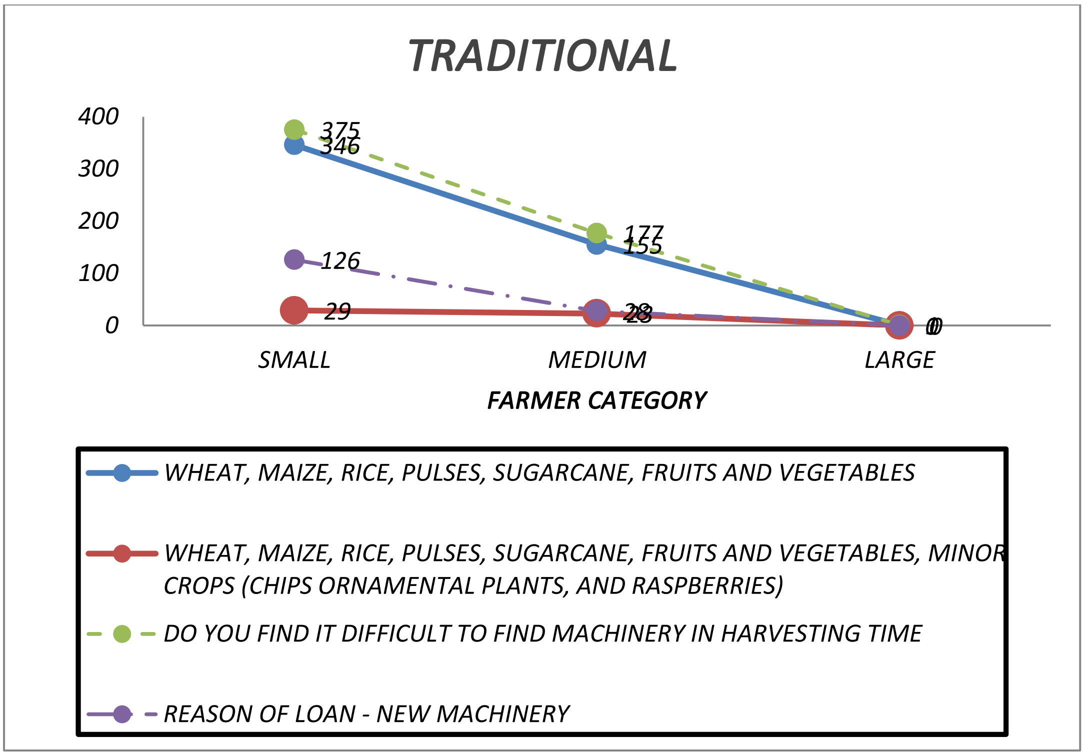
Fig. 4.6 : Different Categories of Farmers are Comfortable in Sharing their Tools

4.6 ANALYSIS BETWEEN DIFFERENT CATEGORIES OF FARMERS AND DIFFERENT TYPES OF CROP V/S DIFFICULTY IN FINDING MACHINERY AND TAKEN LOAN FOR IT

To find the difficulty in hiring machinery our main focus is to explore in what type of farming farmers willing like traditional, traditional and modern and what hurdles they face while finding the equipment. Sharing of tools along with the distance are further focus on category of the famers, kind of crops they have and their difficulty to find machinery and their reason of taking loan. This analysis describes traditional and modern kind of farming which further relate with the category of the farmer: small, medium and large. Table 4.7 represents different kind of crops that the farmers have with traditional, traditional and modern techniques. Figure 4.7 also describe the farmers interest in hiring machinery and loans. This analysis reaches up to the result that most of the farmers in the small category have found difficulty in hiring machinery and due to this reason they are falling under the burden of loan, because of this issues they are committing suicide.

Table 4.7 : Category of the Farmers with Different kind of Crop, Difficulty in Hiring Machinery and their Reason of Loan.

		CROPS		HM	LOAN
	FARMER CATEGORY	WHEAT, MAIZE, RICE, PULSES, SUGARCANE, FRUITS AND VEGETABLES	WHEAT, MAIZE, RICE, PULSES, SUGARCANE, FRUITS AND VEGETABLES, MINOR CROPS (CHIPS ORNAMENTAL PLANTS, AND RASPBERRIES)	DO YOU FIND IT DIFFICULT TO FIND MACHINERY IN HARVESTING TIME	REASON OF LOAN - NEW MACHINERY
TRADITIONAL	SMALL	346	29	375	126
	MEDIUM	155	23	177	28
	LARGE	1	0	1	0
TRADITIONAL MODERN	SMALL	1	1	2	1
	MEDIUM	1	0	1	0
	LARGE	4	1	0	4



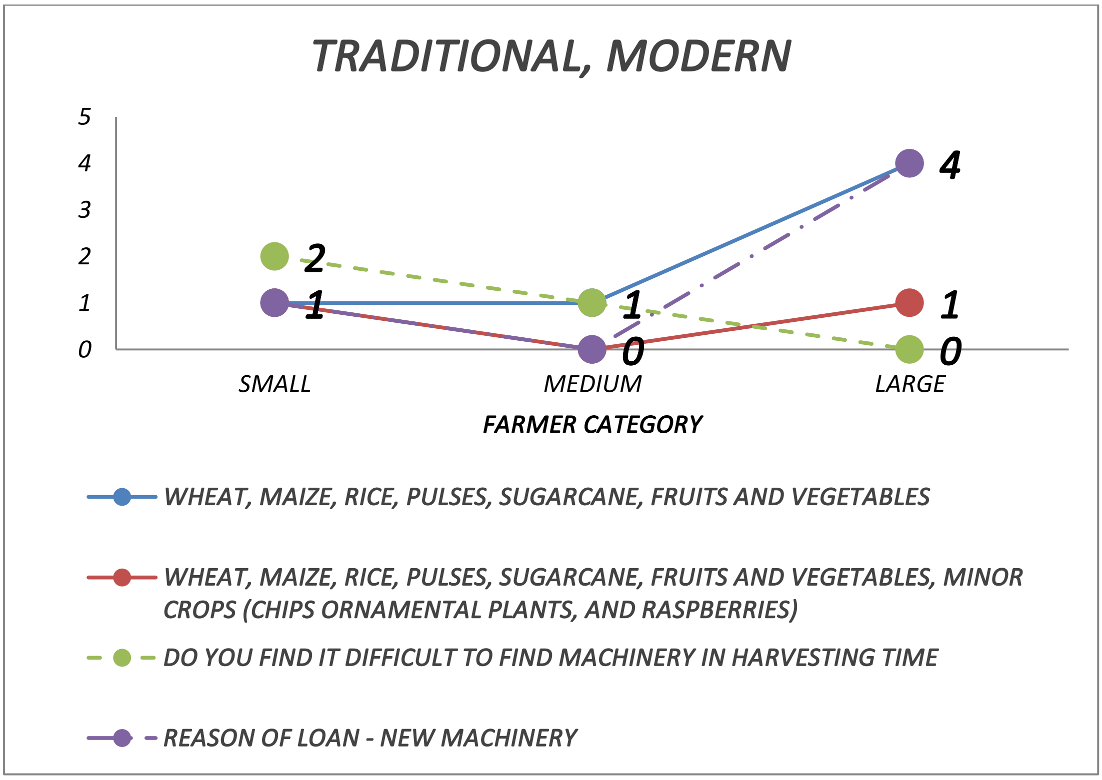


Fig. 4.7 : Analysis between Traditional and Mixed Farming, Types of Crop they grow v/s Difficulty in Finding Machinery and Loan.

4.7 ANALYSIS OF SURVEY TAKEN IN DIFFERENT VILLAGES

With the view of this whole research, we are in concern to rectify the farming related issues in India. As the literature reported that researchers around the globe are doing their well efforts in India but there is a very seldom study in the Punjab so in order to view this concern in the present study our center of attention is Punjab domicile. In the same state we have surveyed in different district with numerous villages. This table 4.8 describes these are the areas covered while collection of data which include number of villages and their count of survey. These areas include Nakodar, Bathinda, Hoshiarpur, Jalandhar, Ludhiana, Moga, Mehsampur, Lambra, Gurdaspur, Phillaur and Madhya Pardesh. Figure 4.8 found that maximum collection of the data is from Bathinda district i.e 462 and also farmers from the same district showed keen interest in renting and sharing.

Table 4.8: Area v/s Count of Surveyed Areas

VILLAGE	AREA	COUNT OF SURVEY
ALEWALI NAKODAR	**NAKODAR**	**56**
BAATH NAKODAR		
BUDHI		
BUDHI NAKODAR		
BURI NAKODAR		
GANDHRAN NAKODAR		
KHURSHEIDPUR NAKODAR		
KOTLA JANGAN NAKODAR		
MAHERU NAKODAR		
NAWA PIND DAKHNI NAKODAR		
NAWA PIND TALKA NAKODAR		
NAWA PIUND NAKODAR		
PANDORI NAKODAR		
SIDHWA NAKODAR		
SIDHWAN NAKODAR		
SIDHYA NAKODAR		
SOHAL KHURD NAKODAR		
MUHEM NAKODAR		
NAKODAR		

VILLAGE	AREA	COUNT OF SURVEY
DHADDA HUNDAL		
BANGER MUHABAT SINGH BATHINDA	**BATHINDA**	**462**
BURJ BATHINDA		
GEHRI BARA SINGH BATHINDA		
GHOSO KHANA BATHINDA		
JATRI BATHINDA		
JODHPUR PAKHAR BATHINDA		
MANAK KHANA BATHINDA		
MANSA KALAIN BATHINDA		
KOT BHARA BATHINDA		
NAWA PIND NAKODAR		
VILLAGE ADAMWAL,BHARWAIN ROAD,HOSHIARPUR	**HOSHIARPUR**	**8**
VILLAGE AJJOWAL,NEAR VERKA MILK PLANT,HOSHIARPUR		
VILLAGE SANCHAN,HOSHIARPUR		
VILLAGE BASSI GULAM HUSSAIN,HOSHIARPUR		
LAMBRA PIND JALANDHAR	**JALANDHAR**	**21**
MIRPUR PIND JALANDHAR		
SARAI KHAAS JALANDHAR		
VILLAGE VARYANA PO:- BASTI BAWAL KHEL JALANDHAR		
VPO NANDANPUR JALANDHAR		
VPO TEHANG, TEHSIL PHILLAUR, DISTT JALANDHAR		
NAGRA PIND JALANDHAR`		
VPO PURAIN JAGRAON LUDHIANA	**LUDHIANA**	**1**
VILLAGE DROLLI MOGA	**MOGA**	**2**
MEHSAMPUR	**MEHSAMPUR**	**1**
MAHUWAL	**MAHUWAL**	**1**
LAMBRA	**LAMBRA**	**1**
KALANAUR GURDASPUR	**GURDASPUR**	**7**
LAKKAR MANDI , PHILLAUR	**PHILLAUR**	**1**
VILLAGE-BHUNWASA,TEHSIL BHATNAGAR, DISTRICT UJJAIN ,MADHYA PRADESH	**MADHYA PRADESH**	**1**

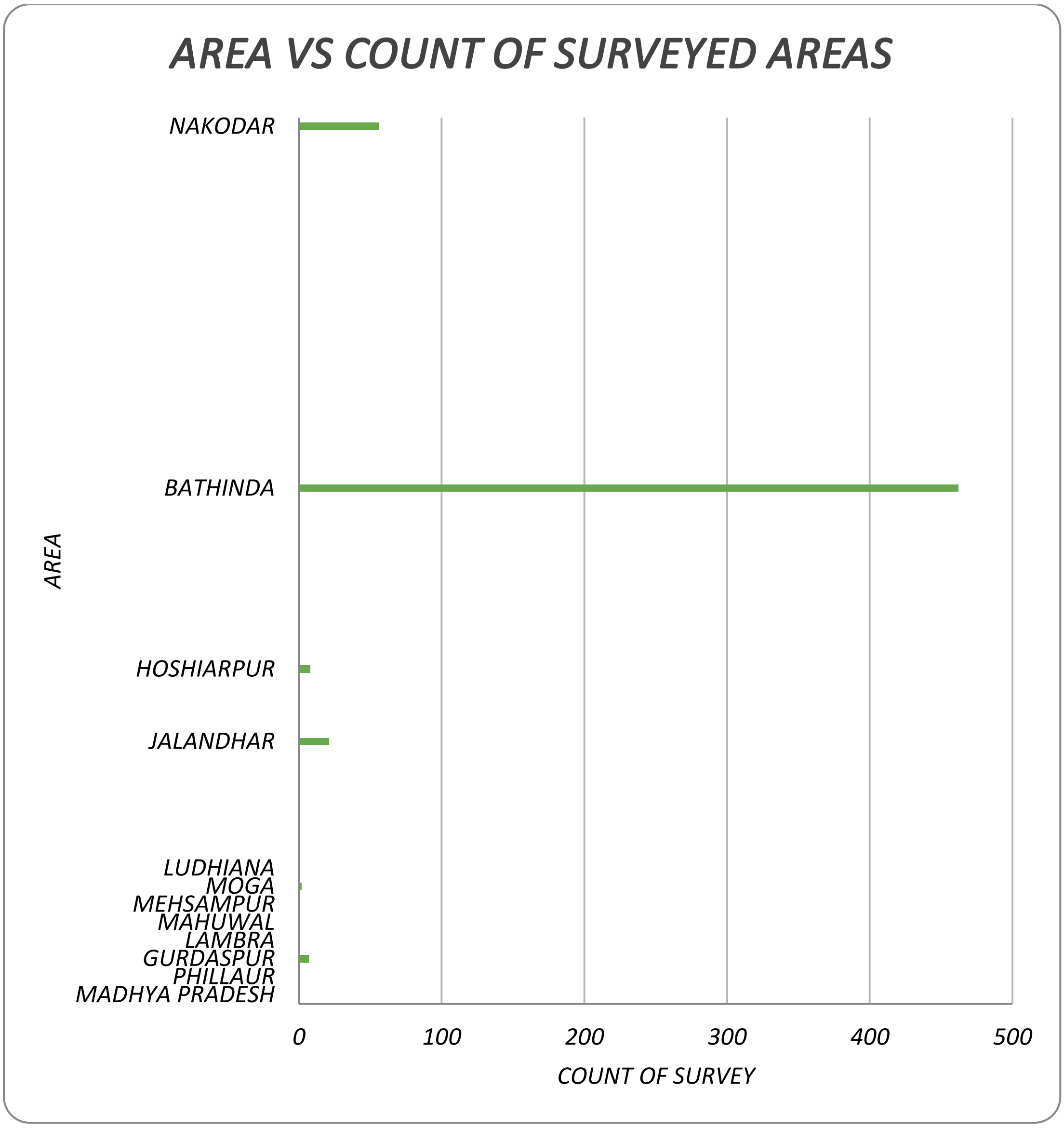


Fig. 4.8: Areas covered while Collection of Data.

4.8 INTRODUCING MACHINE LEARNING TO DATASETS

4.81 Feature selection

The overview of the data has been represented in this figure 4.9 which tells us about mean, standard deviation, Minimum and maximum value of the collected data set of 562 farmers. Average value is represented by mean, and standard deviation is used to find the difference in value and the other range of values are represented by maximum and minimum.

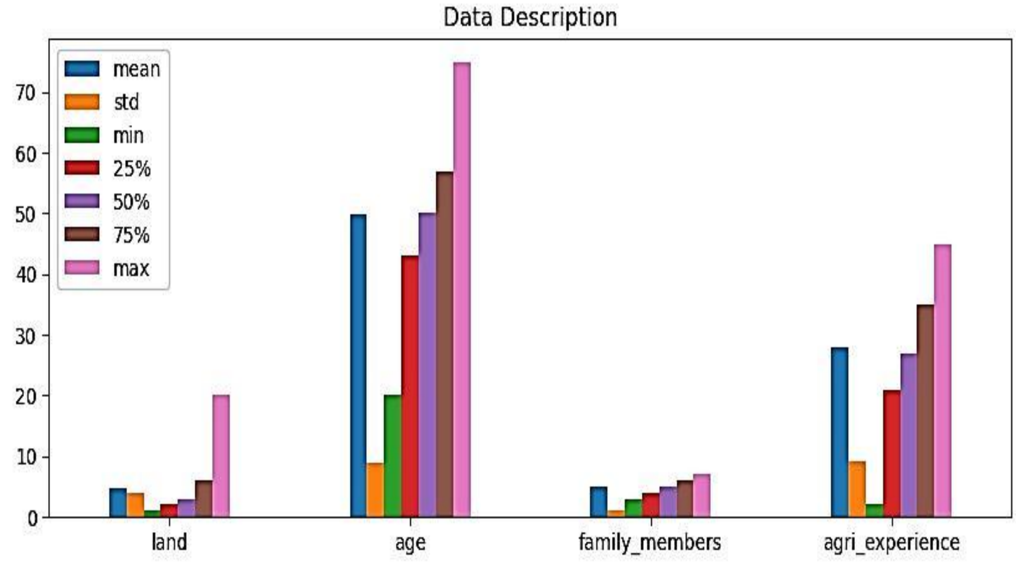


Fig.4.9 : Overview of Collected Data.

The association between knowledge of new technologies and agricultural experience is seen in Figure 4.10. To facilitate this, farmers are classified into three categories: small, medium, and big. This result indicates that small farmers, despite their increased agricultural expertise, are still unaware of farming implements. It is used to represent symmetrical data. However, as their agricultural expertise grows, they become more conscious of new instruments. Large farmers includes that with the age of agriculture experiences all the farmers have the awareness of new tolls.

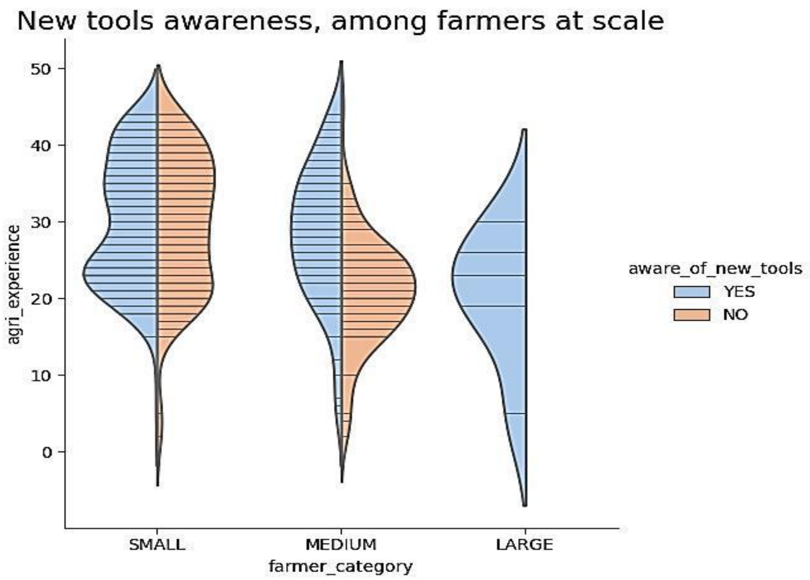


Fig.4.10 : New Tools Awareness with Farmer's Category.

Correlation is a statistical term that quantifies how linearly connected two variables are (meaning they change together at a constant rate).There are two types of correlation. Positive and negative correlation. In case of positive correlation, with the increase of dependent parameters the independent parameters will also increase whereas in the later case with the increase of dependent parameters the independent parameters will decrease. If the value of correlation lies between +1 and -1 then it is named as strong correlation. This matrix represents the correlation between land age family members and agriculture experience. The first row (land) in fig 4.11 represents the best correlation for the agriculture experience with land and no correlation is found b/w the land and family members.

The row 2 ages represents best correlation with the agriculture experience and vice versa .The 3rd row family member has the best correlation with the land.

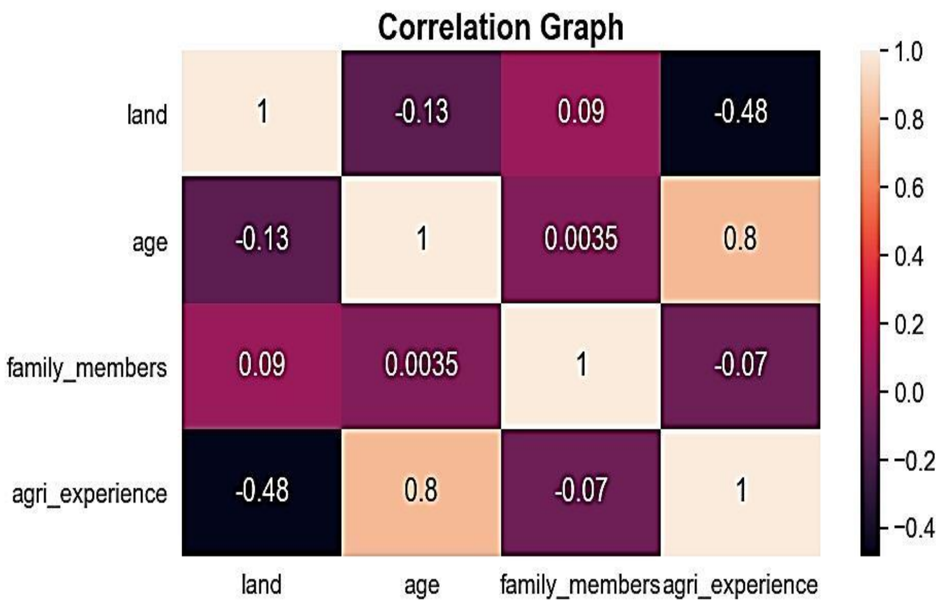


Figure 4.11 : Correlation Graph of Land with Different Parameters

The figure 4.12 shows the association between the interest in machinery and mobile application. 95.7 percent of the farmers want to hire equipment, while 96.4 percent want to use a mobile application. We discovered a correlation between these two variables, which is that farmers who wish to hire equipment are particularly interested in mobile applications.

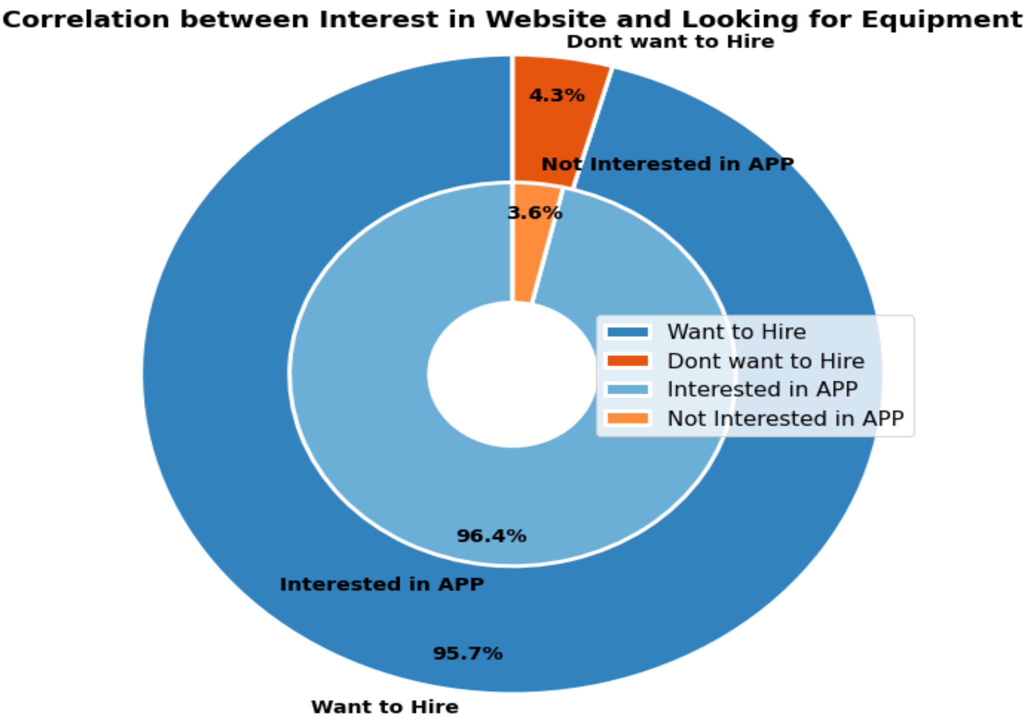


Figure 4.12:-Correlation b/w the Farmers interested in Hiring Machinery and Mobile Application

4.9 MODEL SELECTION

In orde to view the number of farmers/users who wish to hire machinery from the selected smart tillage we have tested the data set by different classifiers named logistic regression , k-neighbour,decision tree and neural network. Herein, survyed data of 562 farmers has been used to predicit the accuracy of the trained model.Our training dataset consist of 446 observations and the testing data set consist 116 observations.We input the trained data set into the model,and trained the model and then we get the predicition for test data set and trained data set.

The figure 4.13 depicts the receiver operating characteristics curve of the true positive and false positive rate. The TP rate is the percentage of positive observations that were properly projected to be positive. The FP rate is the percentage of all negative results that are mistaken for positive ones. In this graph we are getting close to Max area which is y. Our model is giving real predictions and the model predictions are not due to a chance.

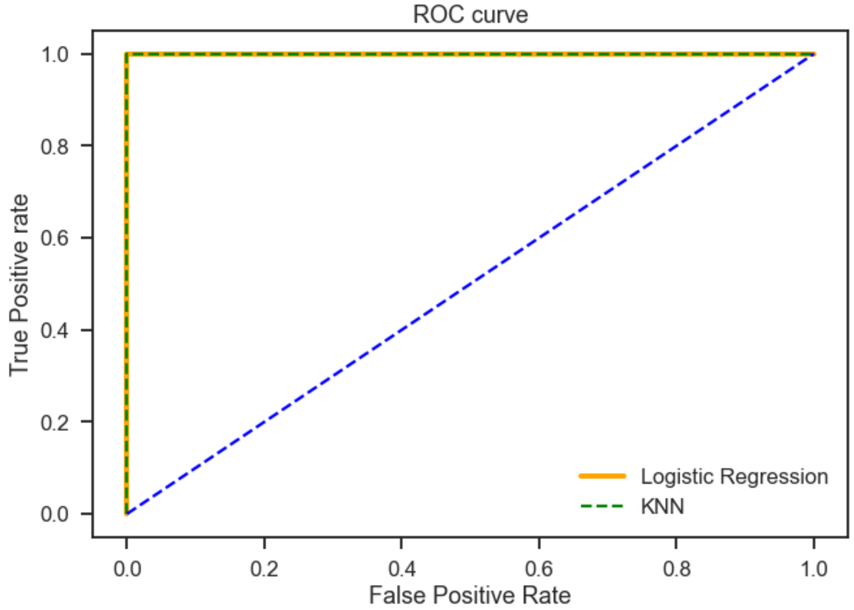


Figure 4.13: ROC Curve b/w True Positive Rate and False Positive Rate

The graph 4.14 represents Precision v/s loss of training data. It also shows the relationship between the model's understanding of the dataset and improvement in classification power with respect to the increasing number of epochs. With each passing epoch, our model is learning and hence the loss is decreasing and precision is increasing. The formula for the Precision is

Precision = True Positives / (True Positives + False Positives)

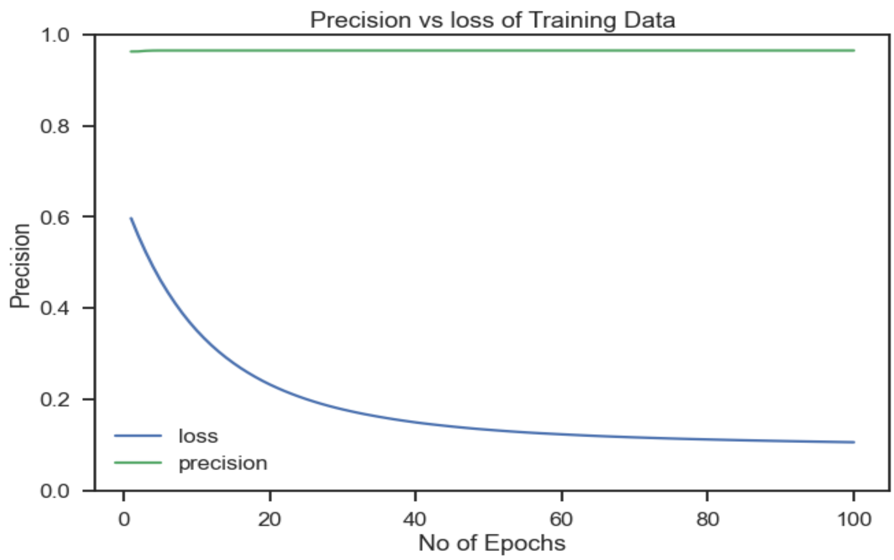


Figure 4.14: Precision v/s Loss of Training Data.

The graph 4.15 on left reflects that our neural network is learning well as both the training and validation loss functions are decreasing with an increasing number of epochs. The plot on right depicts the model's training and validation performance as our model is learning where the precision score is increasing; both the training and validation performance metric is improving similarly.

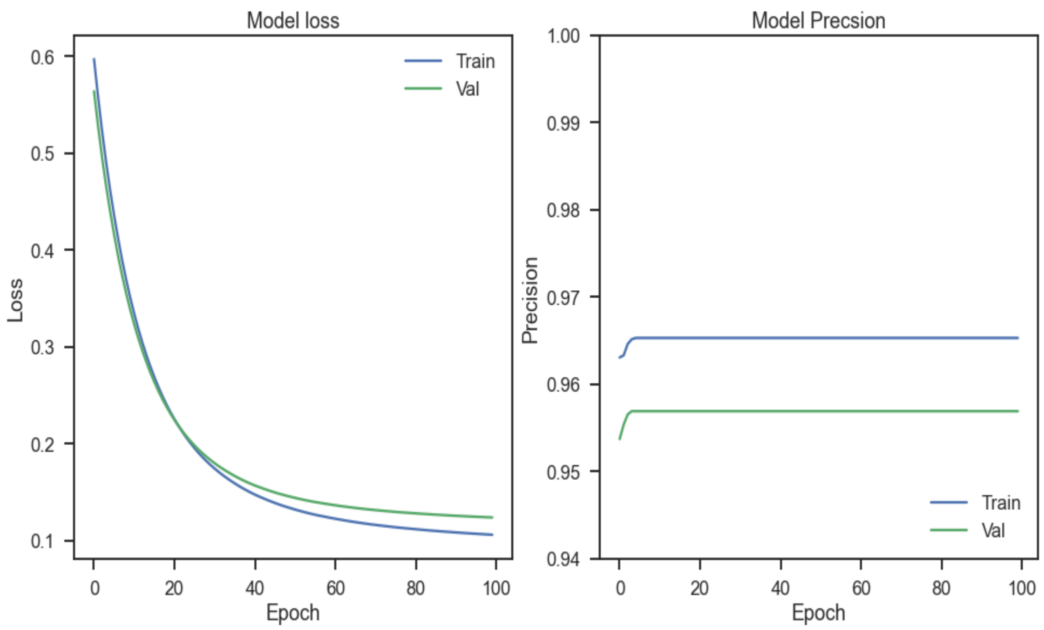


Figure 4.15: Loss V/S No. of Epochs

4.10 COMPARITIVE ANALYSIS OF THE MACHINE LEARNING ALGORITHM

Three machine learning classifiers are used for the analysis: logistic regression, k Neibors classifiers, and a decision tree. This research indicates that how many farmers would want to use our technology. To summarize, the model was trained using training data that included 446 observations, and then was tested on a test data set of 116 farmers. By using the decision tree, we're obtaining the highest accuracy of the model from our test observations of 116 people.Figure 4.16 depicts the comparitve nalaysis by different classifiers models. The formula to calculate accuarcy is

Accuracy = (TP + TN)/(TP + TN + FP + FN).

Where *TP, FN, FP and TN* represent the number of true positives, false negatives, false positives and true negatives.

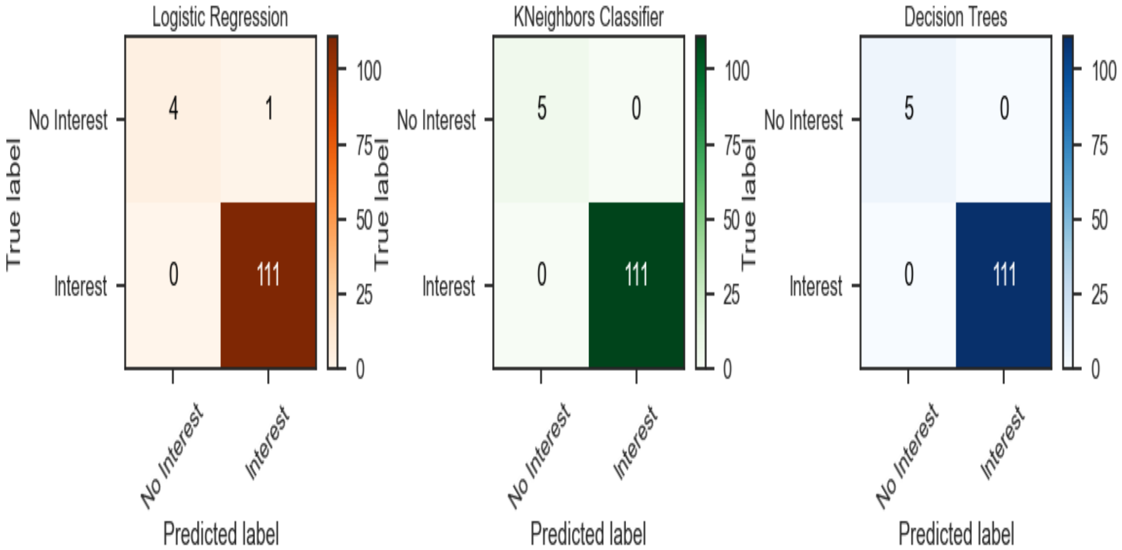


Figure 4.16: Comparative Analysis by Different Classifier Model

Logistic Regression: Out of 5 negative predictions, the model gave one false positive, and out of 111 positive predictions got all of them correct.

K-neighbors Classifier: Out of 5 negative and 111 positive predictions, this model got all of them correct.

Decision Tree Classifier: Out of 5 negative and 111 positive predictions, our tree model got all predictions correct.

After performing classification with different models like Logistic Regression, K-Neighbors Classifier, and Decision Trees. Decision Trees and K-Neighbors were the better performers; we have chosen Decision Trees as our model of choice because of it being a non-distance-based algorithm, its white-box approach and excellent performance on our dataset.

4.11 DEMAND SUPPLY ALGORITHM

With a rise in demand, the supply is likely to react accordingly. In our system, April and May are the harvesting months. So, additional tools and equipment will be needed in these months. Since considering this, we have implemented the demand supply algorithm to estimate how the price fluctuation would be in the market. To make the predictions, many variables were collected from the dataset.

To anticipate price variations, this algorithm is to be performed with n iterations. On one specific day of harvesting month, the system has 200 tools and there are 2000 people looking for the Equipment. Analyzing equipment demand, the system will raise prices. This may lead to financial ruin for small-scale farmers. We've adopted an idea to make sure farmers get a pop-up notification on their smartphones that harvesting season is approaching, and also you can save money by booking equipment ahead of time. Therefore, we've created a data collection with characteristics like city, latitude, longitude, day, month, year, temperature, humidity, Equipment, size, and availability. We have utilized the Google astro-library and open layer library to locate the farmers. Forecast will be utilized to predict the weather of the area. The snapshot for the data set is given below in figure 4.17

Name	city	latitude	longitude	altitude	day	month	year	temp	humidity	precipitation	is_rain	is_snow	is_storm	is_fog	equipment	size	price	requirement	availability
Sachin	agartala	23.88	91.25	15	1	1	2019	19.4	69	0	0	0	0	0	trolley	medium	4319.7	213	205
Raj kumar	agartala	23.88	91.25	15	2	1	2019	19.5	59	0	0	0	0	0	grain_ discharger	large	3609	138	327
Mohit Arora	agartala	23.88	91.25	15	3	1	2019	19.3	62	0	0	0	0	0	rotary_ tiller	small	1964	259	334
Ram singh	agartala	23.88	91.25	15	4	1	2019	17.7	68	0	0	0	0	0	tractor	large	4814	210	414
Dev Raj	agartala	23.88	91.25	15	5	1	2019	17.9	67	0	0	0	0	0	drum_ seeder	small	482	155	336
Jatinder pal singh	agartala	23.88	91.25	15	6	1	2019	18.6	67	0	0	0	0	0	frail_ mower	large	4839	178	271
Iqbal singh	agartala	23.88	91.25	15	7	1	2019	19.2	70	0	0	0	0	1	spray	small	2354	202	193

Figure 4.17 : Base Data set

From the dummy data set we predicted the Mean price per day. Figure 4.18 depicts the snapshot for the mean price per day of the Equipment

	equipment	day_num	month	day	requirement	availability	price
0	rice_planting_machine	0	1	1	165	287	3073
1	seed_drills	1	1	1	177	304	4182
2	tractor	2	1	1	200	268	4608
3	trolley	3	1	1	190	309	3589
4	rice_planting_machine	4	1	2	207	246	3073

Figure 4.18: Mean Price per Day of the Equipment

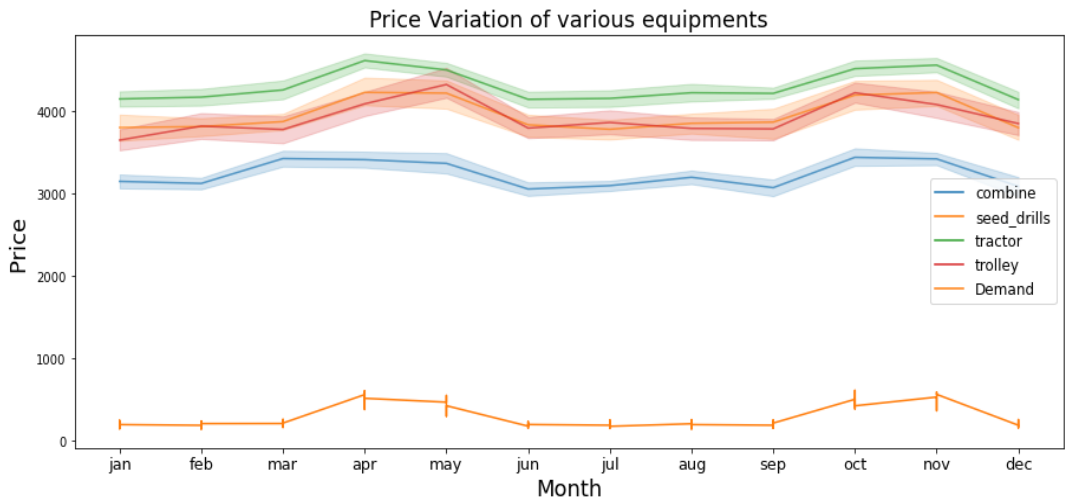


Figure 4.19: Price Variations with Months

4.19 estimate the monthly price fluctuation for various equipment. Harvesting months are April and May, while fall harvest occurs in October and November. Thus, we can see that in April, May, and October the market price will reach a high while in the other months it will be in balance. It is anticipated that with a rise in demand, prices would increase.

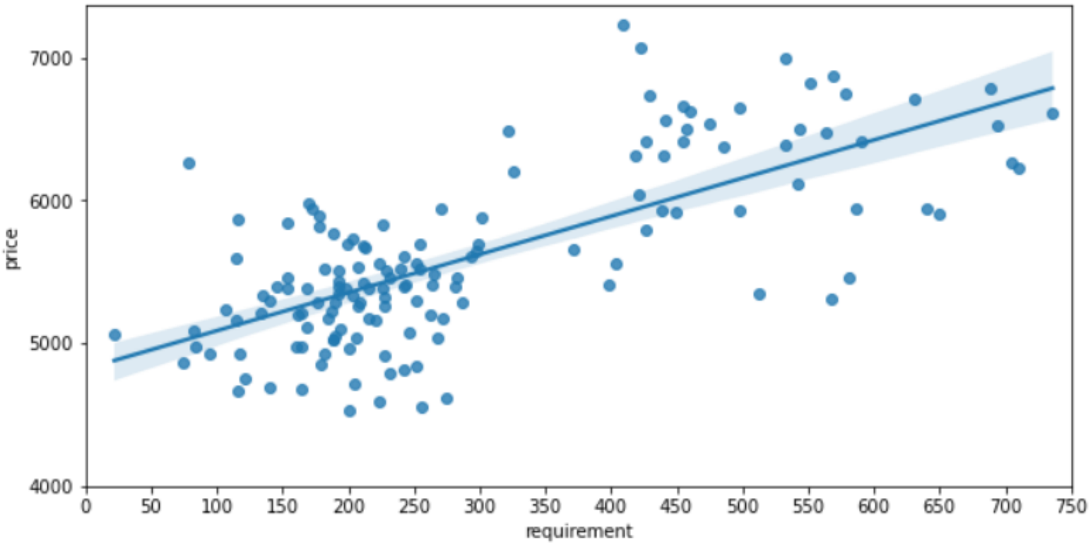


Figure 4.20: Demand Price Plot

According to the regression shown in figure 4.20, the demand-price connection is increasing. The increase in the demand will certainly result in a rise in pricing. The Y-axis represents the pricing, while the X-axis displays the demand for the tools and equipment. In harvesting season, the price fluctuates because of increased demand for equipment. With this system, for farmers with plenty of equipment, leasing their unneeded tools may be a fantastic financial opportunity.

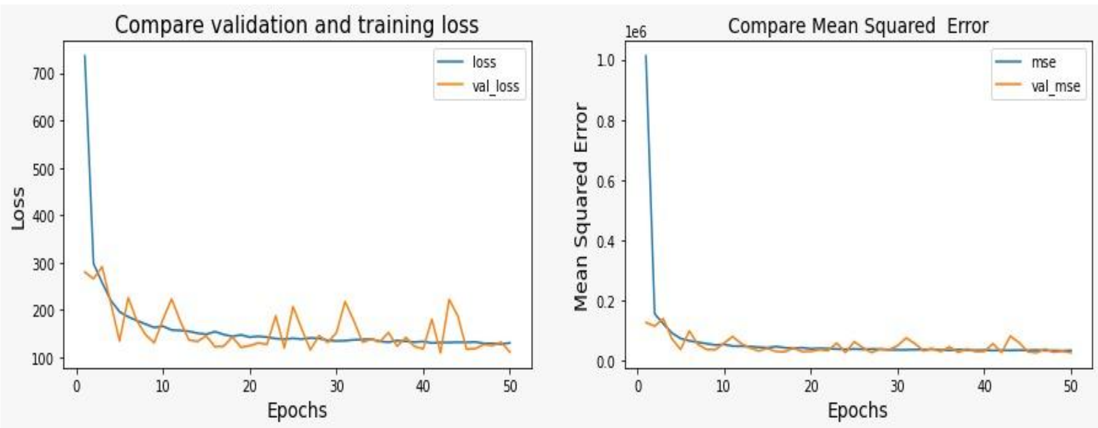


Figure 4.21: Validation and Training Loss

Figure 4.21 predict the validation and training loss. These graphs are suggesting the learning of our neural network, with increasing epochs our model is learning successfully on both training and validation datasets.

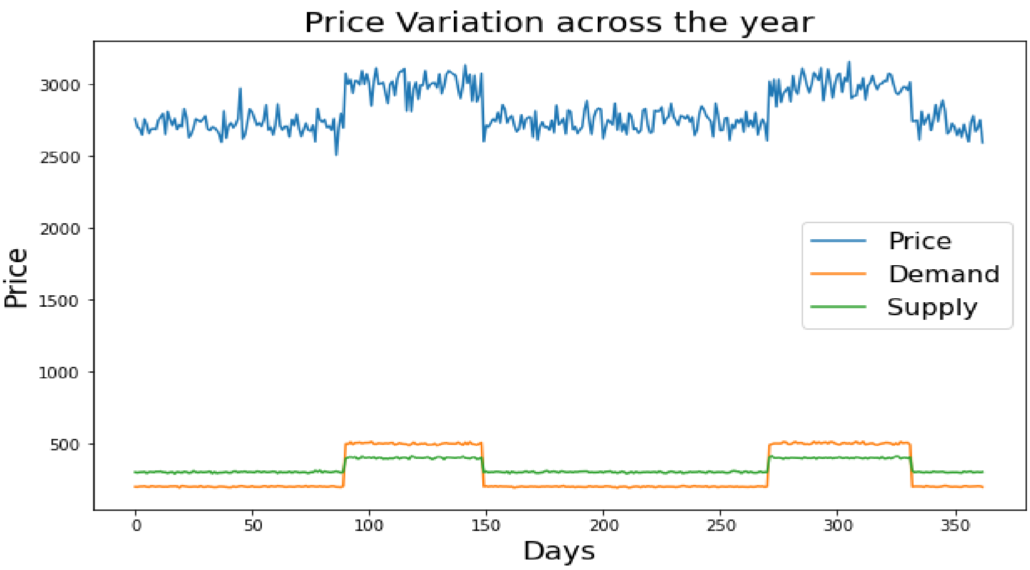


Figure 4.22: Price Variation Across the Year

Figure 4.22 shows the general forecast that with more demand, pricing would rise. The blue crest and trough indicate the price, while the orange and green lines show demand and supply.

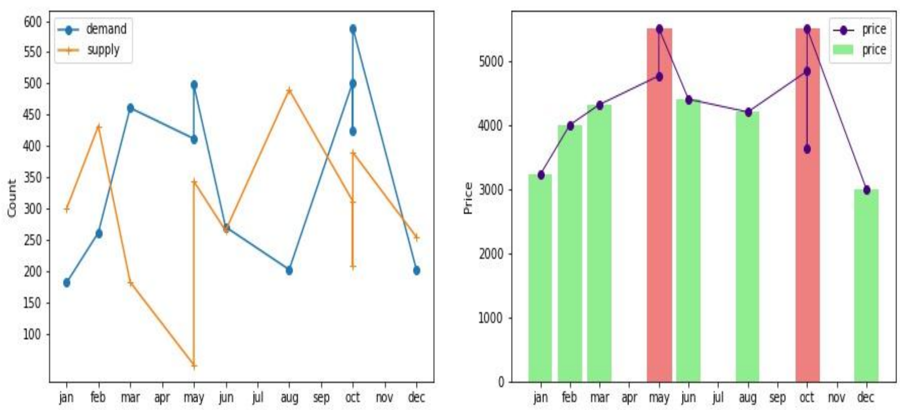


Figure 4.23: Supply Demand Analysis for Tractor

The graph in figure 4.23 explains the relationship between prices, supply and demand. We can see the prices being divided into two sections of high and low demand. Instances with similar supply numbers have varying prices as per the demand, when the demand is increasing, the price increases as well which describes a positive correlation between demand and price.

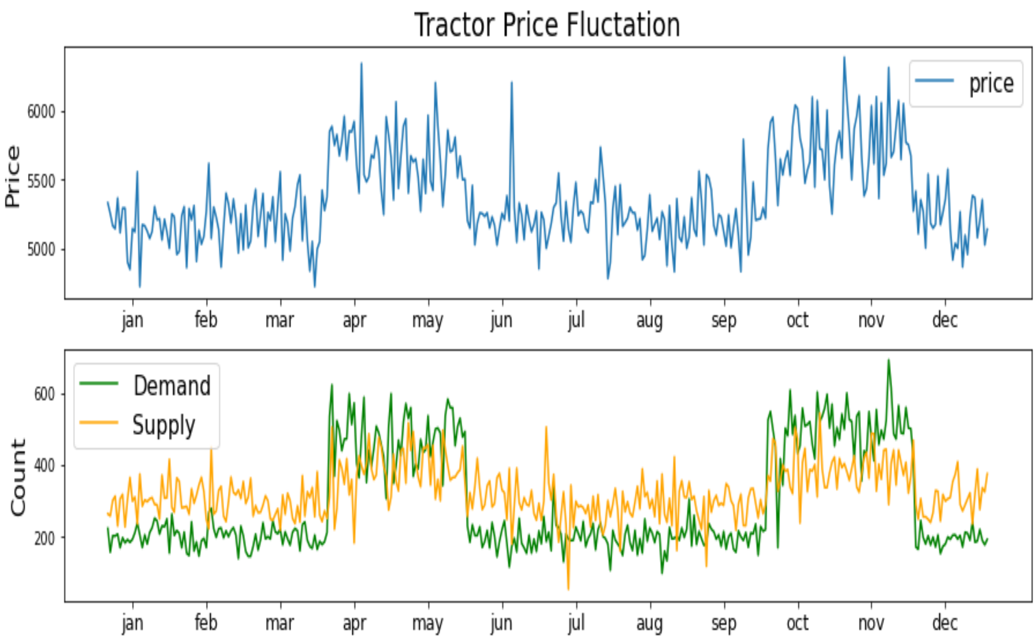


Figure 4.24: Tractor Price Fluctuation

Figure 4.24 predicts the fluctuation in the price of equipment name tractor. The upper graph is reflecting the price variation across the year. And the lower graph is showing the demand and supply fluctuations of the equipment. Together the plot is explaining the effect of demand and supply variations on price. We can see that, in times when the demand has surpassed the supply the prices have spiked to higher values and vice versa.

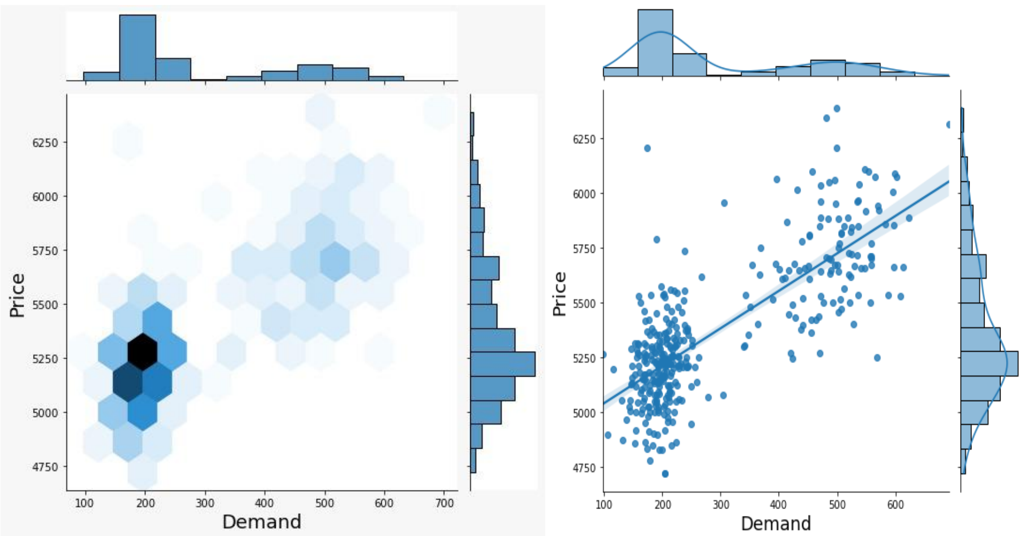


Figure 4.25: Price Plot with Demand

We can observe two dense price sections in figure 4.25; the lower price section is having low demand while the higher price section is having higher demand. With demand being more than 400 in number, the prices are highly probable to be me more than the case of lower demand.

4.12 CHOOSING THE OPTIMAL MODEL

After training and evaluating various models on our training and testing dataset, we found that Decisions trees performed best on our dataset with a mean absolute error of 138.33. The runner-up model was a neural network with a mean absolute score of 127.13 followed up by our lowest performer and base Linear Regression model. Figure 4.26 depicts the comparative study of machine learning algorithm

The formula to calculate Mean Absolute Error is :

$$MAE = \frac{\sum_{i=1}^{n} |y_i - x_i|}{n}$$

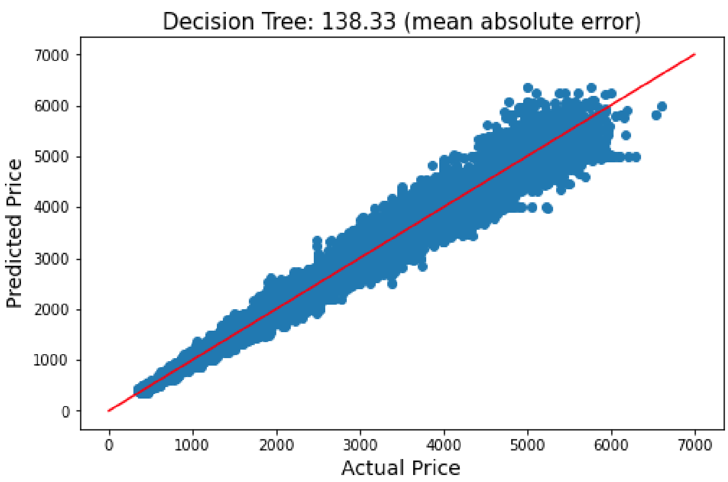
MAE = Mean Absolute Error

y_i = Prediction

x_i = True Value

n = Total Number of Data Points

Hence we have chosen Decision Tree Regressor as our optimal model.



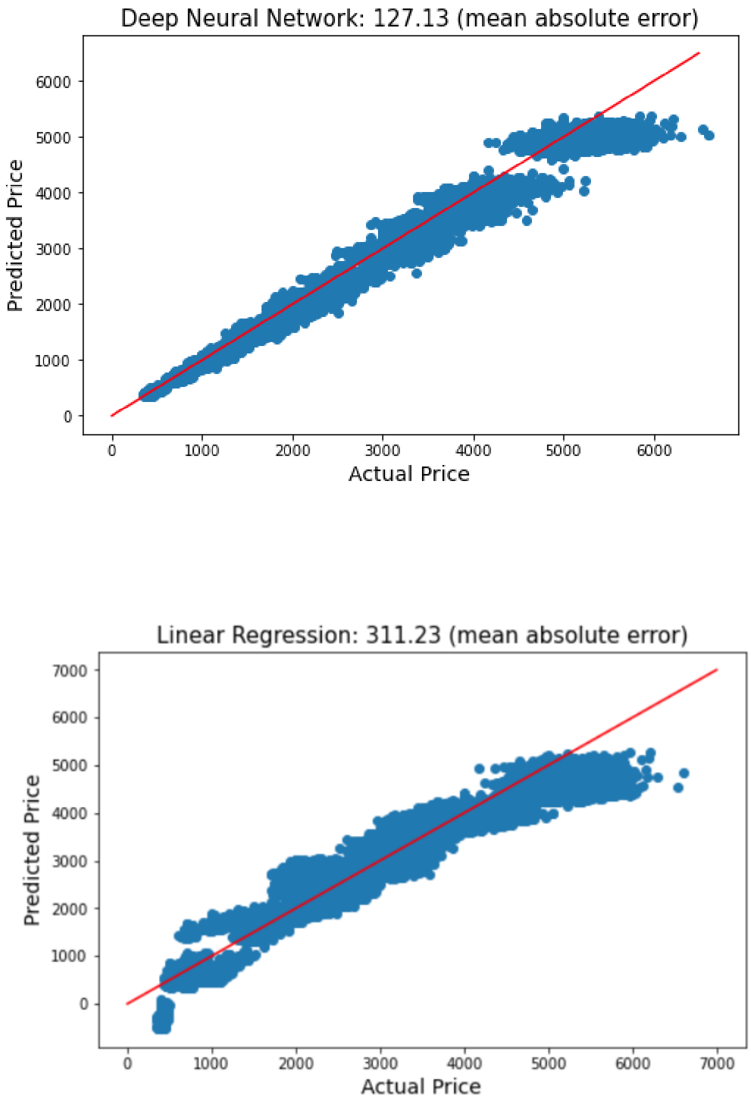


Figure 4.26: Comparative Analysis of Machine Learning Algorithm

4.13 SUMMARY

In this chapter we have discussed about the various inferences that we have find out from the data set. To achieve the observations we have divided the data set into trained data set and tested data set. In the training set, 70% of the data is chosen for usage while the remaining 30% is utilized as a test dataset.To achieve first objective, collection of data of 562 farmers was done. The analysis of these effected parameters has been discussed. After the analysis, we have used various Machine learning algorithm. Different classifiers like Decision tree, K-Neighbour and linear regression are used to predict the accuracy of the model. A framework named Smart-Tillage is developed.Smart-Tillage is a platform where user has to register before they get permitted to rent or hire any equipment through this application. Additionally, we've applied the demand-supply algorithm to anticipate the fluctuation in the peak season. After training and evaluating various models on our training and testing dataset, we found that Decisions trees performed best on our dataset with a mean absolute error of 138.33. The runner-up model was a Decision tree regressor with a mean absolute score of 138.33 followed up by our lowest performer and base Linear Regression model. Hence we have chosen Decision Tree Regressor as our optimal model.

Chapter – 5

CONCLUSION AND FUTURE SCOPE

5.1 THESIS SUMMARY

This chapter includes the summary of the work accomplished in the thesis and the future perspective of the work. The first objective of this work was to survey the farmers of Punjab from different districts. Herein, 562 farmers were surveyed from different villages of Punjab. A deep analysis of the survey made us draw several inferences, the biggest and significant one among them is why a better farm yield is not being achieved. The issues that beset agriculture were also examined and explored from different parameters namely, education level of the farmers, land they hold, their awareness level, use of mobile/ smart phone, burden of loans, reason of loan and interest in hiring machinery. It was found that lack of awareness on the part of the farmers make them inaccessible to new technology. which is being used across the world in farming operations. Poor financial condition of the farmers, esp. small and marginal, is another constraint. To run their farming operations, they borrow loans from commission agents or private agency, which gradually sucks them up. On the other hand, even landlords lack knowledge about the latest methods of production and follow the outdated traditional production methods. To address these critical issues, the present study has developed a framework named SMART TILLAGE in which farmer can rent and hire the equipment. The study has also developed the concept of machine leaning model in the system .The study finds that the Decision Tree is the best technique in machine learning and hiring of tools and equipment. In addition, SMART TILLAGE aims to improve the quality and efficiency of farming with thrust on enhancing the farmer's life style by eliminating his tough tasks and hard work. The main focus of this thesis is on equipment sharing and renting to build the smart farming. On the searching module, we have embedded the recommender system. Filtering, prioritizing, and quickly delivering relevant information is required on the internet due to the massive number of choices. To offer consumers with customized content and services, recommender systems search through large volumes of dynamically produced data. Based on the selected system, there are two types of recommendations namely, content based and collaborative based recommendation. Farmer's recommendation is related to the parameters searched by the user. Our system can provide the recommendation to the end user/ farmers.

A framework smart tillage can accommodate the farm equipment sharing and renting considering seasonal fluctuations, market, demand and pricing and the crop cycle. The demand and supply algorithm is applied on static data. Active demand, passive demand and short term projections are used in this study. To anticipate price variations, this algorithm is to be performed with n iterations. After training and evaluating various models on our training and testing dataset, we found that decisions trees performed best on our dataset with much accuracy in mean absolute error. In this study, a Google API and open layer map are used to find the current location of the farmer who is renting the equipment. The farmer who wants to hire the equipment will be updated with the exact distance, travelling cost and the number of days he wants to hire the equipment.

To upgrade the knowledge of the farmers, an internet based mobile application has been developed which can be used to advertise equipment. This mobile application is directly linked to the surveyed data that most of the farmers are having in their smart phones. It means farmers can easily book and rent their tools and equipment from their smart phones. Furthermore, the developed model shall be modified as per the real dataset created in the upcoming times. In the concluding note, it is worth to mention that the problem presented in this thesis is beneficial for the farmers. This kind of the research is thus very helpful to resolve the issues that are related to farmers and farming operations. Thus this research has the potential to strengthen agrarian economy besides uplifting the condition of the farmers.

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3. M. Rakhra and R. Singh, “Materials Today : Proceedings A study of machinery and equipment used by farmers to develop an uberized model for renting and sharing,” *Mater. Today Proc.*, no. xxxx, 2020, doi: 10.1016/j.matpr.2020.11.784.

4. Manik Rakhra, Ramandeep Singh, Tarun Kumar Lohani, Mohammad Shabaz, "Metaheuristic and Machine Learning-Based Smart Engine for Renting and Sharing of Agriculture Equipment", *Mathematical Problems in Engineering*, vol. 2021, Article ID 5561065, 13 pages, 2021. https://doi.org/10.1155/2021/5561065.

DEVELOPMENT OF THE INTERNET-BASED SMART AGRICULTURAL RESOURCE SHARING FRAMEWORK

Agriculture in Punjab is in serious crisis. In this proposed system we are going to develop a full-fledged system for farm equipment renting/sharing for the farmers in which the farmers can post their surplus/not used equipment. This framework will make a high impact on the society issues as the farmers are continuously struggling to get cleared with the burden of loans, low productivity, and fear of not getting the equipment on time and are finally committing suicide. For that purpose, a system needs to be created which includes all the details of geographical locations, equipment and tools, cost and availability of resources. The various features of this proposed system are:-

1) Farmers will get the right equipment at the right time.
2) The need for taking for buying the equipment is an unnecessary burden on the farmers. This proposed work will help with this major burden of the farmers.
3) Ownership costs for the machinery and equipment include depreciation, taxes, insurance and housing so the custom hiring scheme often a better choice than trying to keep old equipment in operating condition.
4) Farmers who are living in the rural areas will get aware with the new technology's equipment and they can access a new type of equipment in the very peak time by paying a little amount of many for these days.
5) This kind of system may help to generate the new jobs for the youngsters to operate the agriculture's equipment.

*** Required**

1. Name:*

____

____

2. Village:*

____

____

____

____

____

____

3. Land :*

- ☐ 20 CANALS
- ☐ 1 ACRES
- ☐ 2 ACRES
- ☐ 3 ACRES
- ☐ 4 ACRES
- ☐ 5 ACRES
- ☐ 6 ACRES
- ☐ 7 ACRES
- ☐ 8 ACRES
- ☐ 9 ACRES
- ☐ 10 ACRES
- ☐ 11 ACRES
- ☐ 12 ACRES
- ☐ 13 ACRES
- ☐ 14 ACRES
- ☐ 15 ACRES
- ☐ 20 ACRES

4. Age: *

____

5. Gender: * ☐ Male ☐ Female

6. What is your educational qualification: *

☐ Illiterate ☐ Secondary ☐ Graduation

7. Number of family members: *

☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ More than 6

8. Domestic expenses per month: *

☐ 10000-25000 ☐ 25000-50000 ☐ More than 50000

9. How many years of experience in agriculture?* ______________________

10. Under what category do you belong *

- ☐ Small Farmers (20 canals, 1 - 4 acres)
- ☐ Medium Farmer (5-10 acres)
- ☐ Large Farmer (11-20 acres)

11. Is your farm registered with the public authority? *

☐ Yes ☐ No

12. What kind of farming is done? *

☐ Traditional ☐ Modern

13. Types of Crop Crops *

☐ Wheat, Maize, Rice, Pulses, Sugarcane, Fruits and Vegetables ☐ Minor Crops (Chips Ornamental Plants, And Raspberries)

14. Do you have availed loan or not? *

☐ Yes ☐ No

15. Reason of Loan *

☐ Land Development ☐ New Machinery

☐ Plantation, Fertilization ☐ Education

☐ No Loan

16. Where do you get a loan? *

☐ Government Bank ☐ Cooperative Bank

☐ Aarti ☐ No Loan

17. Do you have any special training for the following? *

☐ Agriculture ☐ Modern Machinery ☐ No

18. Which of the following machinery tools do you have? *

☐ Tractor ☐ Plough

☐ Cultivator

☐ Cultivator Seed Drill

☐ Reaper

☐ Fresher

☐ Maize Huller

☐ Tiller Seed Drills

☐ Seed dryer machine

☐ Rice His Gasifier

☐ Arrow Tiller ☐ Combin

☐ No Tools

19. Do you need an operator to operate machinery tools? *

☐ Yes ☐ No

20. How many miles will you be ready to transport to your farming tool for processing? *

☐ 3 km ☐ 5 km

☐ 10 km ☐ More than 10 km

☐ No Tools

21. Annual income from agriculture *

☐ 50000-200000 ☐ 200000-500000

☐ More than 500000

22. Do you need cold storage? *

☐ Yes ☐ No

23. Would you like to rent a missionary tool? *

☐ Yes ☐ No

24. Whenever the time of the harvest comes, do you have trouble finding or finding machinery tools? *

☐ Yes ☐ No

25. Do you participate in agricultural training programs? *

☐ Yes ☐ No

26. Would you love it if you built a mobile app that was easy to find or search for a missionary tool online at a low rate on rentals? *

☐ Yes ☐ No

27. Do you own a Smart Phone? *

☐ Yes ☐ No

28. Phone number:

____

DECLARATION

I give my consent for the information provided by me to be used in educational and research purposes. I would not claim any right on the research or results drawn from this study and data.

Date: ________________ Signature