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*Retraction*

# Retracted: Implementing Machine Learning for Supply-Demand Shifts and Price Impacts in Farmer Market for Tool and Equipment Sharing

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

## References

[1] M. Rakhra, A. Bhargava, D. Bhargava, R. Singh, A. Bhanot, and A. W. Rahmani, "Implementing Machine Learning for Supply-Demand Shifts and Price Impacts in Farmer Market for Tool and Equipment Sharing," *Journal of Food Quality*, vol. 2022, Article ID 4496449, 19 pages, 2022.

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*Research Article*

# Implementing Machine Learning for Supply-Demand Shifts and Price Impacts in Farmer Market for Tool and Equipment Sharing

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Several industries have recently seen the replacement of human labor by automated machinery and equipment. Across the globe, farmers' attitudes on the use of technology in agriculture are divergent. However, although some people are excited and ready to embrace technology, others are cautious and wary of trying new technologies for the first time. The third category is particularly prevalent in underdeveloped nations such as India, owing to a lack of competence, a lack of effective translation, and most crucially, a lack of financial resources. It is fruitless for the government to attempt to resolve these difficulties due to the fact that they do not take into consideration the changing circumstances and input needs of each agricultural group. Smart Tillage is a cutting-edge framework that was developed to solve the challenges listed above. In India, a decision-based smart engine for the rental and sharing of tools and equipment has been developed, which leverages machine learning methods to proceed towards a selection of tools and equipment. The option is entirely reliant on a variety of input variables, including crop kind, harvest time/month, crop equipment needed, harvest type, and the amount of money available for rental. Additionally, an ideal recommendation engine driven by content and collaborative-based filtering will provide the farmer's requirements depending on their requirements. In terms of escalation, the proposals would be cost-effective and excellent since they would need little changes in training, technique improvements, and resource management via a new rent-share model similar to that used by Uber. In this work, demand and supply algorithms are used to define market equilibrium, and the results are shown in graphs. This includes discussion of a variety of demand and supply parameters, their impact on market equilibrium prices and quantities, and their effect on shifting demand and supply curves. The many sorts of elasticities (demand, cross-price, supply, income, and so on) are examined, as well as the ramifications for pricing systems that may result from these elasticities.



## 1. Introduction

India is an agriculture-based country where significant agricultural progress has been made via the use of machines. By 2051, we have to sustain over 10 billion individuals, which would require 70% expansion in the worldwide production of food products [1]. There are 1.3 billion farmers on the planet, and a large number of them are still without access to tools and current innovation [2]. In numerous developing countries, farmers cannot put resources into advancements because of little landholdings and credit limitations, which can enable them to build efficiency and procure better lives [3]. Farms that strive toward innovative farming methods contribute to improved management of equipment and other resources employed and provide beneficial benefits, such as generating more money and producing crop yields. Also, it assists in greater output or cost reduction with less effort and providing quality food grains with more ecologically friendly procedures. Under the green technology development or green revolution, more emphasis is given on the farming which is eco-friendly and simultaneously yields good products on the field [4]. However, taking these benefits to the farm will rely on farmers' willingness to use modern technology in their fields and on their farm-specific profitability [5]. Higher use of intelligent services is essential to improve farm profitability and meet the increased food demand. In Punjab, most farmers opt to lease land since farmland size is decreasing [6]. Farmers' financial situation would worsen throughout the year because of the absence of the monsoon and the variable pricing of agricultural products owing to climatic changes. 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 socioeconomic and census, the proportion of rural families in Punjab without land is among the highest in the nation.

For decades, rising farm debts have been a problem in the state. However, there has been a bulk of farmer suicides in India due to rising living costs, policy changes, water shortage, and higher land rental lease costs (particularly in Punjab) [8]. Worse still, the current climate crisis has resulted in a rise in crop fires and a decrease in annual precipitation. In Punjab, 86% of farming households were under debt; between 2000 and 2015, more than 16 thousand farmers died by suicide for not being able to repay loans [9]. Nearly 1,100 farmers in Punjab have lost their lives each year owing to the weight of debt. These data support the 2020 report. Many districts in Malwa have experienced the most damage [10]. This research is intended to showcase how planners interact with technology-driven plans. Modern data-based agriculture positively impacts, providing a sustainable and profitable livelihood while decreasing damage to the environment to properly analyze modern agriculture's role in sustainable decision-making [11]. This research will cover all of the essential steps of information-based agriculture, collecting data from agricultural fields and using variable-rate equipment settings.

In order to obtain raw materials and components, turn these raw materials and parts into completed goods and deliver these finished items to merchants or consumers; a supply chain (SC) may be characterized as an integrated system that syncs a number of connected business operations.

The supply chain is the coordination and integration of procurement, manufacturing, distribution, and demand planning. This kind of planning involves making judgments at the strategic, tactical, and operational levels. Supply chain optimization models are being developed to run these processes. The purpose of this study is to evaluate the literature; assess and classify the works based on the decision levels, supply chain subjects, and optimization methods; and recommend future research paths.

*1.1. Farm Mechanization.* In India, only around 30% of farmland is fully mechanized. Nearly 75% of farmers have 1 hectare or less of land [12]. With such small landholdings, farmers are unable to acquire agricultural equipment just for their reasons. Farmers rent equipment from others who lend it economically. Difficulties faced by ranchers include limited access to creditors, no reserving system, high prices, and unreliable transportation. This leads to reduce in the loss of crops for farmers [13, 14]. Farm machines such as tractors are often pricey for small and medium-scale farmers to acquire. As a result, many renters have to pay unfair rents to their owners during the hot season. Machinery is also sometimes not available during a crisis. Half of the Indian farmers have less than four acres of land [15]. Although agricultural machinery is not priced highly high, farmers cannot afford it. Many initiatives to mechanize agricultural operations have centered on the deployment of tractors, but they neglect other crucial equipment.

Renting and sharing is a potential key that enables farmers to borrow equipment at a reasonable cost rather than purchasing the gear [16]. It also allows the agriculturist to be more adaptable in cultivating activities and aids in various crop cycles. Agribusiness is well-known for being both active and thriving. At the moment, Punjab contributes 13% of the offer in Indian food production. At the moment, Punjab supplies 24% of India's total wheat output and 14% of its total rice output [17]. Farm mechanization in Punjab agribusiness has played a significant role in the rapid transformation of crop cultivation techniques; nevertheless, there is still a significant expansion for boosting farming production per unit area and time by increasing cropping power via optimal asset use [18]. An appropriate action furthermore increases the cropping power. Extensive technology is required in order to use the additional cropping capacity. Farm automation is a realistic solution. While substantial contribution has been made by automation to the expansion of the nation's agricultural sector because of the low assets farmers have, most of them are unable to push for mechanization [19]. Most small farmers have to employ machinery to do specialized jobs. In such a short amount of time, only plowing could prepare the growing medium for a particular crop. Since if it rained, the crop would be lost, and the threshing technique was emphasized.

Mechanization focuses on using various sources of power and improved farm equipment, focusing on shortening the workload and 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 has helped increase the yield of crops using irrigation, biological and chemical inputs, fertilizers, pesticides, and mechanical energy [21–25]. Custom hiring farms tend to have more significant inputs and have greater regulation on processes than tractor-owning farms [23]. We can conclude that a machine can do more work for less money when a combustion engine is used. With an IC engine, 1 liter of fossil fuel is equivalent to about 50 employees for 24 hours. Additionally, the human labor 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), but a machine can do significantly larger quantities of effort. For example, it takes more than an hour of hard labor to supply one kWh, which is possible using a tiny machine while using one liter of diesel oil. Productivity is often assessed in terms of market norms. TFP total factor productivity measures agricultural productivity as the ratio of agricultural outputs to inputs. So, various machine learning techniques are used for predictive analysis across the nation. Through the application of artificial intelligence (AI) and machine learning (ML), growers can access increasingly sophisticated data and analytics tools, which enables better decisions, improved efficiencies, and reduced waste in food and biofuel production, all while minimizing negative environmental consequences. Subsequently, health-related issues will also decrease [26–30]. 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 sources of agricultural production [31–35]. Fast and efficient identification of harmful microorganisms is critical for public safety biomonitoring in order to prevent foodborne illness and assure food security. Techniques for detecting microorganisms have progressed throughout the course of time [36, 37]. Literature reported that survey centers on the AI applications according to four mainstays of food security that is food accessibility, food availability, food use, and strength [38].

*1.1.1. Need and Benefits of Hiring and Renting Farming Equipment and Tools.* As an alternative to maintaining own farm machinery, there is a need to encourage rental facilities for medium to small farmers. Farmers have many benefits when leasing equipment, including timely harvests and reduced expenses from paying down payments on equipment [39]. Because farmers depend on complete equipment every day, its significance is crucial to its overall performance. Lack of equipment means low returns and job security are in danger. The leasing system offers landowners the opportunity to increase production quickly. Losing one day of labor may have considerable effects, since agriculture is so time-sensitive. Conventional loan applications and putting down a down payment on equipment purchases require time that farmers do not have. This is a quick and straightforward way to conduct everyday duties on the farm [40–43]. The lease cost is substantially lower than conventional debt, making it more straightforward for smaller and local producers to pay. Producers may negotiate more credit facilities and make fewer payments through leasing [44–47]. Leasing enables farmers to experiment with technology without buying it first.

*1.2. 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. Moreover, the main problem faced by the farmers is the infection or disease caught by the various crops in the field. They encounter huge losses because of this. In agriculture, machine learning allows for more accurate disease diagnosis while conserving energy and avoiding false data. Farmers can upload field images captured by intelligent systems like satellites, unmanned aerial vehicles (UAVs), land-based rovers, smart phones, and tools such as the Climate Field View platform, which can identify potential farm issues and recommend a management plan [48–52].

*1.2.1. 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. Using text classification, we may propose complicated objects like movies without needing "knowledge" of the object itself [50, 51]. 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 [52].

The following are some examples of explicit data collection:

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

*1.2.2. 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 does not need a user sign-in to build a temporary profile [40]. Candidate products are compared with previously rated products and the best-matching things are suggested. This study originated in information extraction and filtering.

*1.3. 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 [53–56]. 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 [57].

Innovation is one of the four Ps of the marketing mix, along with promotion, product, and place. The single income generator of the four P's is the price. Other Ps of marketing, like price elasticity, will contribute to causing price hikes to boost revenue and profits [58, 59]. This is a method of setting pricing on buy and sales orders that rely on several elements, such as a fixed price, per unit quantity break, campaign promotion, special vendor quotation, entry price, and 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 [60]. It is used as a tactical option in response to changing competitive, market, and organisational factors. It is defined as follows: the pricing strategy of a corporation reflects the goals and ideals of the organisation. Typically, this pricing strategy is included into the company's long-term strategic plan. The strategy's goal is to provide a clear approach to pricing setting that is consistent with the other parts of the marketing strategy. The price of goods and services will change as a general rule, but the business model will remain stable during the planning period, which is typically 3–5 years, but in certain industries, may be 7–10 years or more [61, 62]. A long-term pricing plan was set while keeping a flexible price point in mind.

*1.4. 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 conventional 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, ML is concerned with the predictive analysis.

In this briefing, we will present an overview of machine learning approaches that are currently being employed or studied by methodological departments around the nation, with a focus on the United States. In today's environment, there is an enormous quantity of knowledge that is easily accessible. Therefore, it is necessary to assess such data in order to extract some significant information and to develop an algorithm based on the results of these investigations. Data patterns and historical data associations are used to construct algorithms using machine learning, which is an application of artificial intelligence. Machine learning, despite the fact that it is founded on the idea of automation, still requires human supervision. Machine learning requires a high degree of wide generalization in order to produce a framework that operates well on data examples that have not yet been seen. 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 which the latter does not include underlying probabilistic models, while the former does. 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. ML is a computer knowledge from which the provided data can perform various tasks. In order to solve the real-time scenario or applied research problems at the 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 [63–65].

*1.4.1. Learning Tasks.* Supervised, unsupervised learning, and dimensionality reduction are the three main categories of ML. In the former case, data are 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, the dataset 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. (Table 1).

## 2. Literature Review

## 3. Research Methodology

In the first part of the study, data collecting was done. The collected data were taken from 562 farmers in Punjab's Malwa, Majha, and Doaba areas. The questionnaire is open-ended. 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

Table 1: Literature review for renting and hiring of equipment using machine learning algorithm with recommendation system and supply demand based optimization.

| Author (year) | Title | Findings | Relevance |
|---|---|---|---|
| | | Farmer suicide in Punjab | |
| Grover et al. (July 2019) [8] | Farmer suicides in Punjab: causes and suggestions study sponsored by Ministry of Agriculture and Farmers Welfare Agroeconomic Research Centre, Department of Economics and Sociology. | (i) This study depicts the different causes of the farmer's suicide<br>(ii) 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 farmers' suicide in Punjab and their underlying reasons. |
| | | Mechanization | |
| Sarkar (2020) [21] | Agricultural mechanization in India: a study on the ownership and investment in farm machinery by cultivator households across agroecological regions | (i) Mechanized plowing does not substantially reduce labor used for land preparation and in turn increases labor usage for other operations, according to marginal users of agricultural machinery. | Mechanization: we derived the need of mechanization and automation in India from these studies. The emphasis of farm mechanization is on improving agricultural productivity and enhancing availability of tools and equipment and also reducing manpower scarcity. |
| Ghosh (2010) [22] | Determinants of farm mechanization in modern agriculture: A case study of Burdwan district of West Bengal | (i) 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 | |
| Sidhu and Vatta (2012) [23] | Improving economic viability of farming: a study of cooperative agromachinery service centers in Punjab | (i) This study emphasized on the various cooperative agromachinery service centers in Punjab.<br>(ii) It addressed the importance of custom hiring centers in Punjab | We developed the concept of previously existing bespoke recruiting centers in India based on these studies. Additionally, it is necessary to educate farmers who reside in rural regions about custom hiring centers in India. |
| Yarazari (2019) [38] | Custom hiring services of farm machinery in India. | (i) This study focuses on various custom hiring services of farm machinery in India.<br>(ii) Due to their economic situation, small/marginal farmers are unable to acquire agricultural equipment on their own or via institutional finance.<br>(iii) 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) [44] | Role of cooperatives in institutionalization of custom hiring services in Punjab | (i) According to this study, bespoke hiring enables needy farmers to gain the advantages of automation via the utilization of costly equipment.<br>(ii) Some cooperative organizations have taken the initiative to offer agricultural equipment services to farmers on a rental as well as a personalized hire basis | |

Table 1: Continued.

| Author (year) | Title | Findings | Relevance |
|---|---|---|---|
| | | Renting and hiring of equipment | |
| B. Jothi Jahnavi, R. Monica, N. Sripriya C. [42] | Efficient farming, hiring equipment for farmers | (i) Hire service equipment may also have several features, providing the farm family with even more advantages.<br>(ii) Farming becomes more competitive as yields and time savings increase, and costs can be reduced. | From these studies, we deduced the need of developing an uberized model for equipment rental and sharing. |
| Sukhpal singh (2017) [53] | Inclusive and effective are farm machinery rental services in India | (i) In some parts of India, realisation and local creativity have resulted in a trend of custom farm machinery rentals, which began in Punjab. | |
| | | Machine learning algorithm | |
| H. H. Patel and P. Prajapati (2018) [58] | Study and analysis of decision tree-based classification algorithms | (i) The aim of this study is to provide an overview of machine learning techniques that are currently being used or considered by methodological departments across the country.<br>(ii) In today's world, a vast amount of information is readily available.<br>(iii) 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 studies, we introduced the concept of the machine learning algorithm: decision tree classifier/ regressor |
| H. Sharma and S. Kumar (2016) [55] | A survey on decision tree algorithms of classification in data mining | (i) To address the current issues in agriculture, a variety of strategies have been proposed, ranging from database development to selection assistance frameworks.<br>(ii) Structures that use decision tree classifiers have been found to be the most excellent performers in terms of accuracy and robustness among these solutions. | |
| | | Recommendation system | |
| M. B. Santosh kumar and K. Balakrishnan (2019) [61]. | Development of a model recommender system for agriculture using the Apriori algorithm | (i) In this study, two approaches, content-based filtering and collaborative-based filtering, are discussed by the researcher.<br>(ii) Collaborative-based filtering is widely used in the building of recommender systems.<br>(iii) CBL approaches are referred to be memory-based and model-based. | From this study, we incorporated the concept of the recommendation system on the basis of rating and searching of products |
| | | Supply-demand-based optimization | |
| W. Zhao, L. Wang, and Z. Zhang (2019) [63] | Supply-demand-based optimization: a novel economics-inspired algorithm for global optimization. | (i) In this study, authors focused on equilibration methods which may be utilized to address a range of supply and demand issues are implemented in this study.<br>(ii) 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. |

Table 1: Continued.

| Author (year) | Title | Findings | Relevance |
|---|---|---|---|
| Supply-demand-based optimization | | | |
| L. Fleischer, R. Garg, S. Kapoor, R. Khandekar, and A. Saberi (2016) [64]. | A simple and efficient algorithm for computing market equilibria | (i) The supply-demand-based optimization (SDO) method, which is a new meta-heuristic optimization technique, is described in detail in this study. (ii) SDO is a swarm-based optimizer designed to optimize supply-demand relationships. | |
| Jianjun Yu, Qiangqiang Zhu (2015) [62] | Agriculture production planning under supply uncertainty and demand uncertainty | (i) This study focuses on the demand and supply algorithm optimization on a particular market of a crop. (ii) The study focuses on how the market and the company make optimal decision to improve the productivity | Demand-supply optimization with seasonal fluctuations |

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.* 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 are 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 1. 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 these 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.

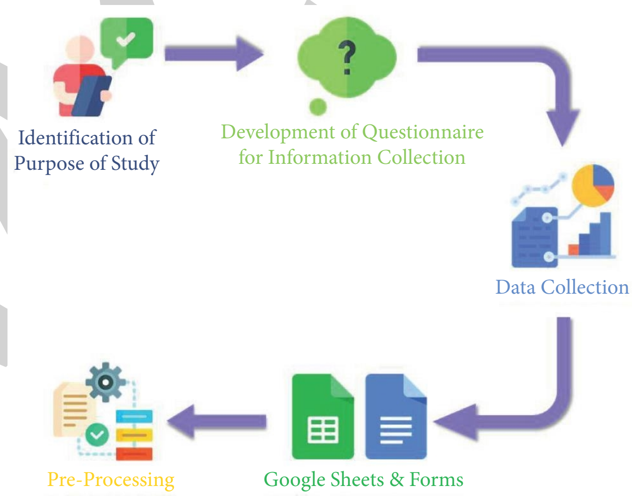


Figure 1: Data collection process (preprocessing).

*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. 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 the 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 the database used is the latest technique, i.e., PostgreSQL for better security and data processing.

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

*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. Recommended systems solve this problem by searching through large volume of dynamically generated information to provide users with personalized content and services. For the recommendation process, the following phases will be used:

(i) Information collection phase
(ii) Explicit phase
(iii) Implicit phase
(iv) Learning phase
(v) Prediction/recommendation phase

Information collection phase will provide recommendations to the end user/farmers. Relevant information will be taken including farmer parameters such as 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 (Algorithm 1).

Step 1: user login into the system
Step 2: click on searching module
Step 3: enter the name of the equipment
Step 4: system applies filter on the basis of parameters entered and user rating
Step 5: provide the best recommendation to the user

On the 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 2 shows the recommendation engine for optimized search. For illustration, if a user wants to search a harvester by giving the inputs such as price, distance, and specifications, 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. In order to make use of this system, the user must first upload his or her item to the system. The demand for equipment is the highest during the peak months of April and October. Every farmer believes that harvesting their crop when it is ripe will result in a higher crop yield in the future. A count of the equipment is performed in this approach, and the number of users who desire to have access is calculated using the information obtained from the count. When there is a greater demand for the equipment, the price will increase. The algorithm provides an estimated equilibrium in a number of iterations that are independent of the number of buyers and proportionate to the number of tools in the marketplace. 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 shows the 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 is ready subsequently increases 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 4. A market's commodity prices represent a potential solution to the optimization problem; as a result, the commodities in that market are assessed as a possible solution to the optimization problem. The most possible option will be chosen, and the old solution will be replaced with the most viable solution available. The commodity price and commodity quantity are located in two separate matrices, since it is a swarm-based technique, as is the commodity price. The matrix for the tool with price is given as shown in the following equation:

**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
**foreach** *item* ∈ *Items* **do**
**if** *item* ∉ *u.rated_items* then
*item.rank* ⟵ rank.according_to_nearest_neighbors ($k$, $u$, *item*)
descending_rank_sort (*Items*)
**return** top ($N$, *Items*)

ALGORITHM 1: Recommendation and optimized searching.

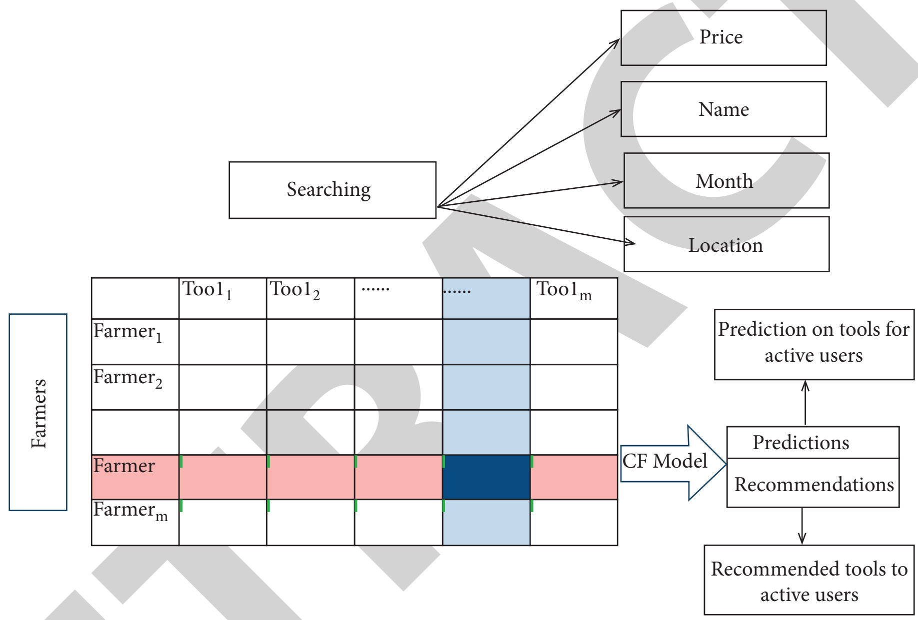


FIGURE 2: Recommendation engine for optimized search.

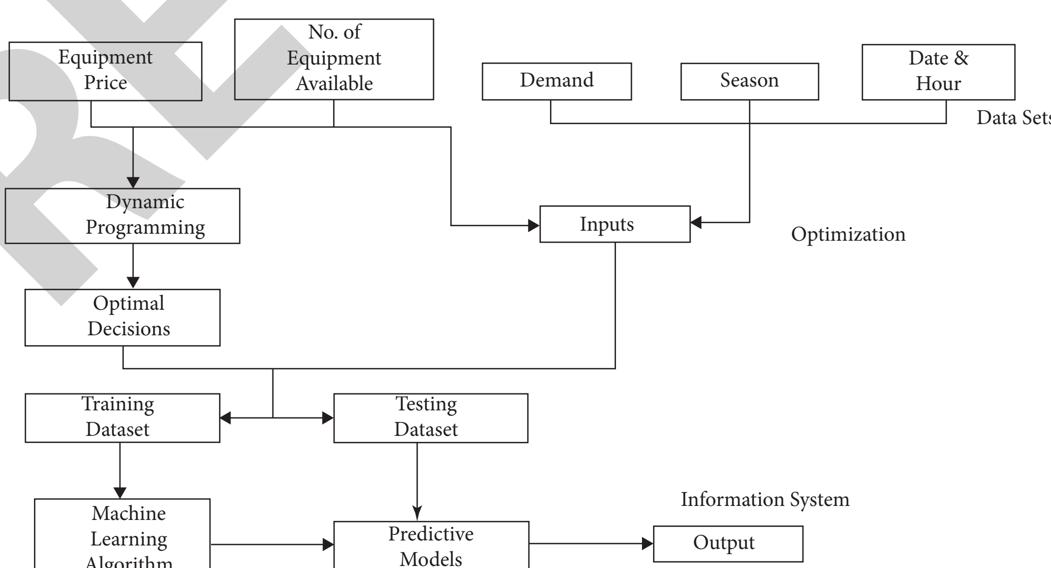


FIGURE 3: Supply-demand optimization.

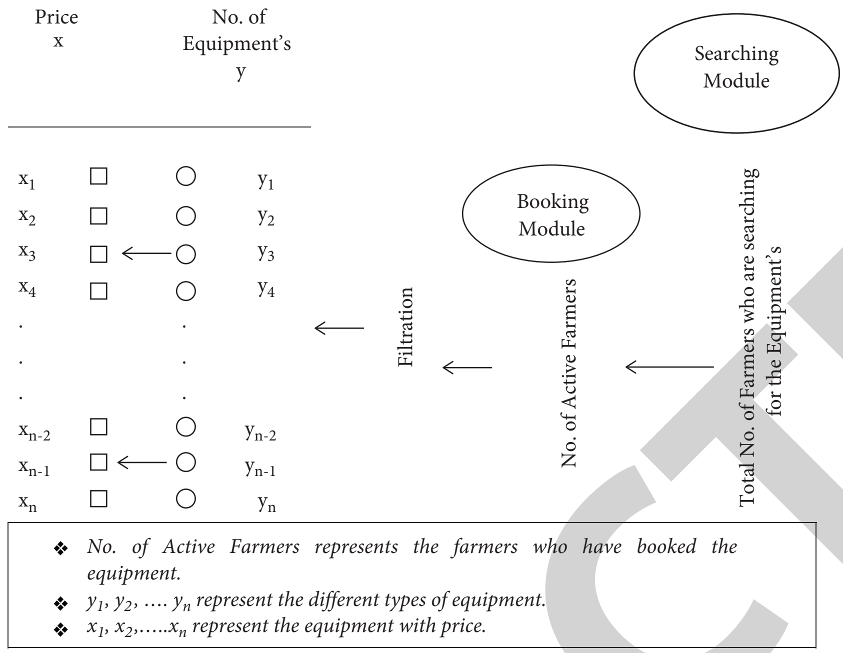


Figure 4: Price prediction based on supply-demand.

$$X = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} = \begin{bmatrix} x_1^1 & x_1^2 & \ldots & x_1^d \\ x_2^1 & x_2^2 & \ldots & x_2^d \\ \vdots & \vdots & \vdots & \vdots \\ x_n^1 & x_n^2 & \ldots & x_n^d \end{bmatrix}, \qquad (1)$$

where $d$ is the actual number of equipment with price in each market $x^j$ ($i = 1, 2, \ldots, n$, $j = 1,2,3, \ldots, d$) and $n$ is the optimized price of the tool after imposing the demand and supply algorithm. The quantity matrix for market users is given as shown in the following equation:

$$X = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} y_1^1 & y_1^2 & \ldots & y_1^d \\ y_2^1 & y_2^2 & \ldots & y_2^d \\ \vdots & \vdots & \vdots & \vdots \\ y_n^1 & y_n^2 & \ldots & y_n^d \end{bmatrix}, \qquad (2)$$

where $d$ is the number of users logged in the system and $n$ is the number of active users.

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. Figure 5 shows the data flow of the proposed work.

The pseudocode used for demand and supply algorithm is given in Algorithm 2.

*3.4.2. Types of Forecasting Techniques.* 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 are based on farmers' search for equipment and the number of tools available.

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

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 does not utilize statistical techniques or examine economic trends.

## 4. Results and Discussion

This part of the research 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. 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. 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

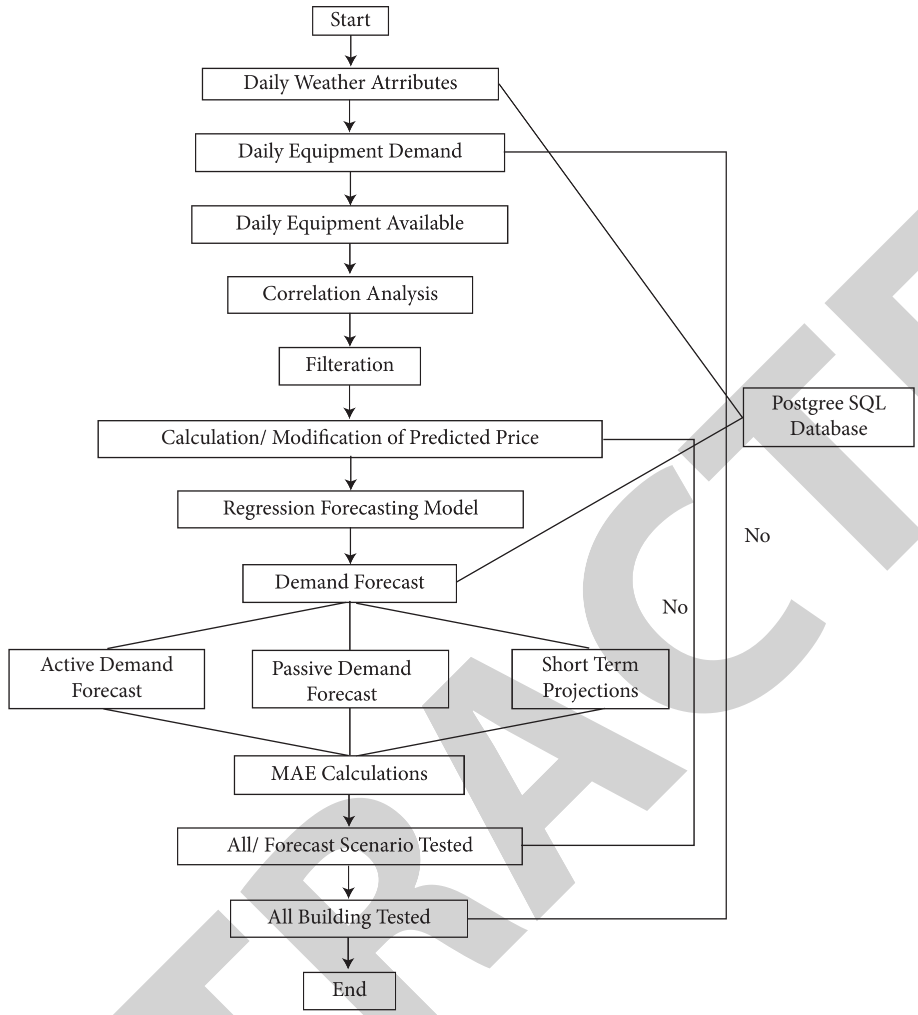


FIGURE 5: Flow of demand-supply.

(1) Start
(2) Identify the equipment demand (ed), weather forecast (wf), supply (s)
(3)
(4) While the criteria are 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 $\mathbf{y_0}$
  (i)Filter the no of farmer who booked a specific equipment $\mathbf{y_1}$
 (b) Determine the total number of equipment with price $\mathbf{x_0}$.
  (i)Filter the booking of specific equipment with price number $\mathbf{x_1}$
(6) Calculate their fitness value **f(x1)** and **f(y1)** by using decision tree regressor
(7) If **f(y1)** is greater than **f(x1)**
 (a) Replace **xi** by new price $\mathbf{x_{i+1}}$ 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 $\mathbf{x_{i-1}}$ 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 the predicted model
(17) End y

ALGORITHM 2: Algorithm for supply-demand optimization.

| | 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_panting_machine | 4 | 1 | 2 | 207 | 246 | 3073 |

Figure 6: Mean price per day of the equipment.

knowledge, under the burden of loans, which tools they are having, what is the reason of loans, and many more. These issues, as well as others, have contributed to the decline of farming in Punjab. This has been taken into consideration via the completion of a socioeconomic level study and the implementation of a technical solution to encourage the rental and sharing of agricultural equipment. Design, build, and deploy an internet-based mobile application for different kinds of end-users that can be used to promote, reserve, rent, and share agricultural equipment. The programme will be available on both Android and iOS platforms. The results of the analysis of these obtained data have been shown by adjusting various parameters.

*4.1. 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 have 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 have created a data collection with characteristics such as city, latitude, longitude, day, month, year, temperature, humidity, equipment, size, and availability. We have utilized the Google astrolibrary and open layer library to locate the farmers. Forecast will be utilized to predict the weather of the area.

From the dummy dataset, we predicted the mean price per day. Figure 6 shows the snapshot for the mean price per day of the equipment.

Figure 7 shows the estimation of 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 high, while in the other months, it will be in balance. It is anticipated that with a rise in demand, prices would increase.

According to the regression shown in Figure 8, the demand price connection is increasing. The increase in the demand will certainly results 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 9 shows 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 10 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.

The graph in Figure 11 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 12 shows the fluctuation in the price of the equipment name tractor. The upper graph is reflecting the price variation across the year. 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.

We can observe two dense price sections in Figure 13; the lower price section is having low demand, while the higher

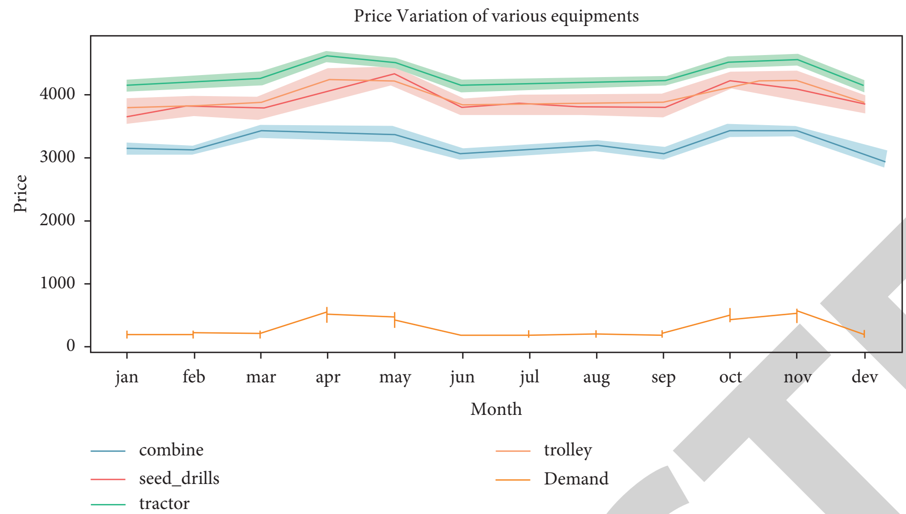


Figure 7: Price variations with months.

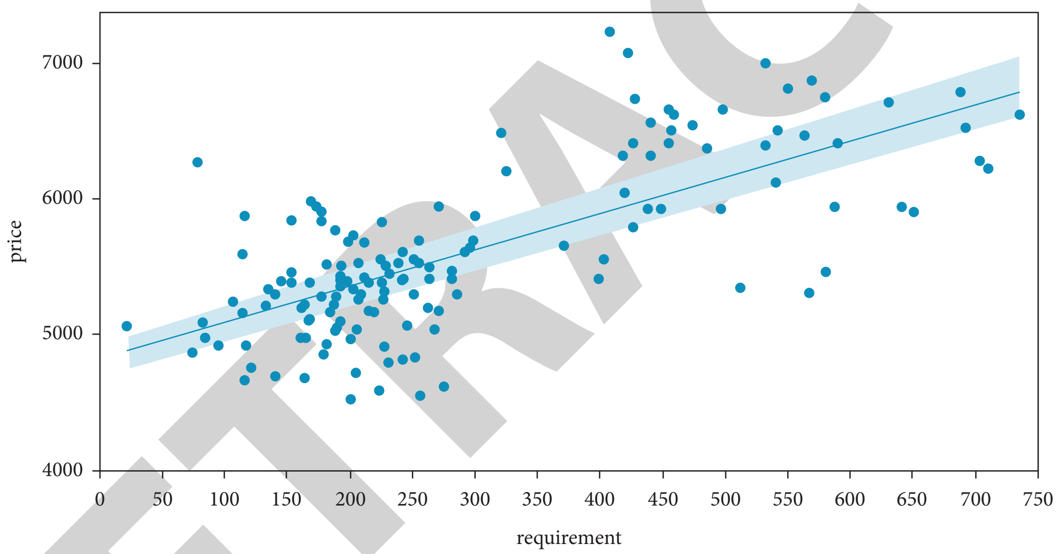


Figure 8: Demand price plot.

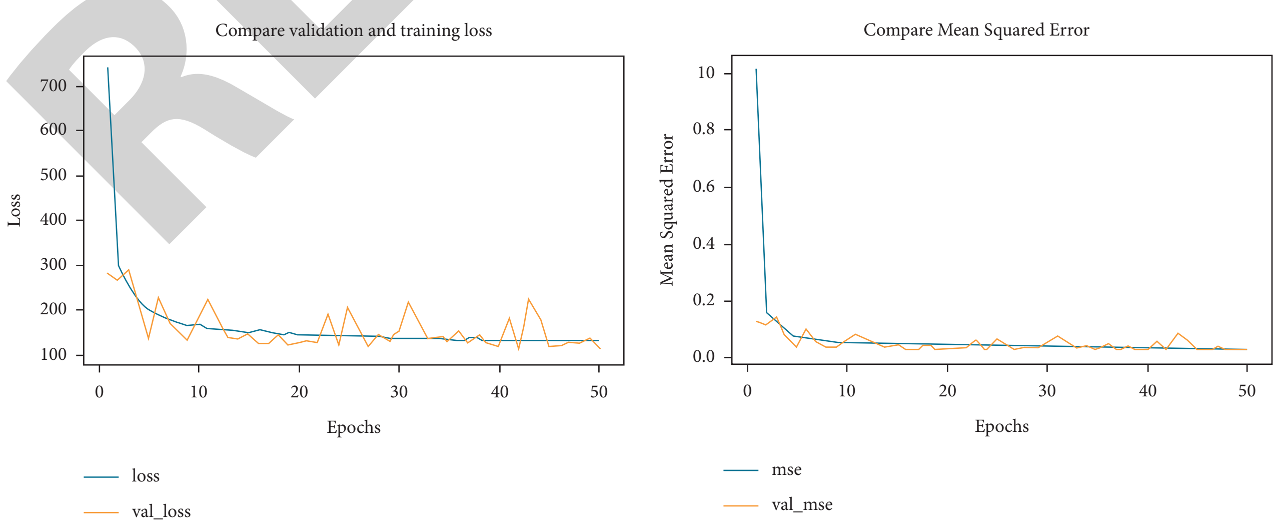


Figure 9: Validation and training loss.


FIGURE 10: Price variation across the year.

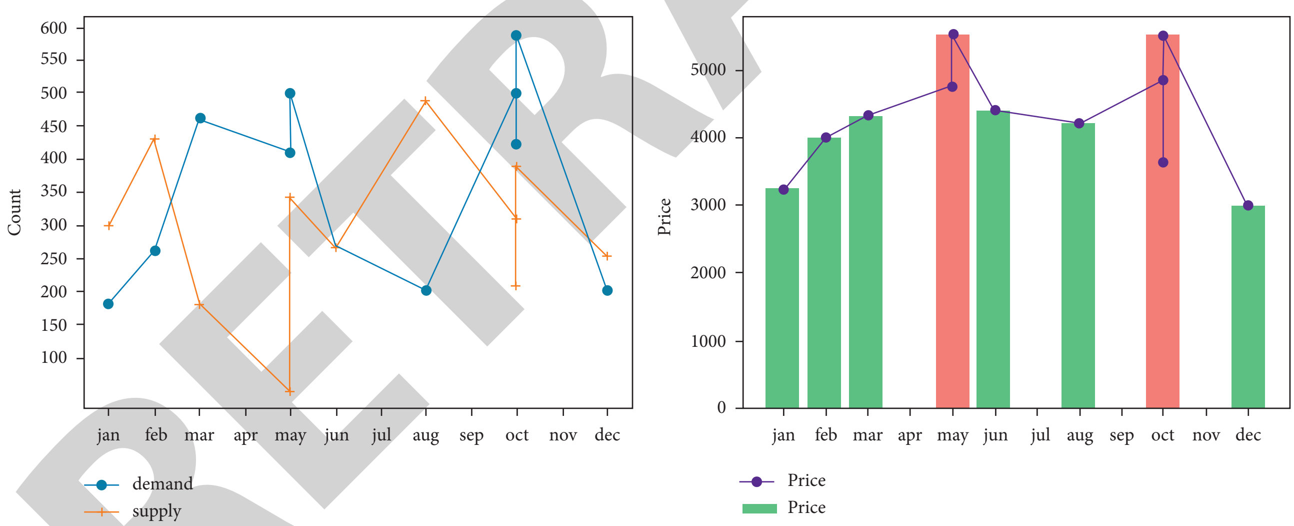


FIGURE 11: Supply-demand analysis for tractor.



price section is having higher demand. With demand being more than 400 in number, the prices are highly probable to be more than the case of lower demand.

*4.2. 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 14 shows the comparative study of the machine learning algorithm.

Hence, we have chosen decision tree regressor as our optimal model.


Figure 12: Tractor price fluctuation.

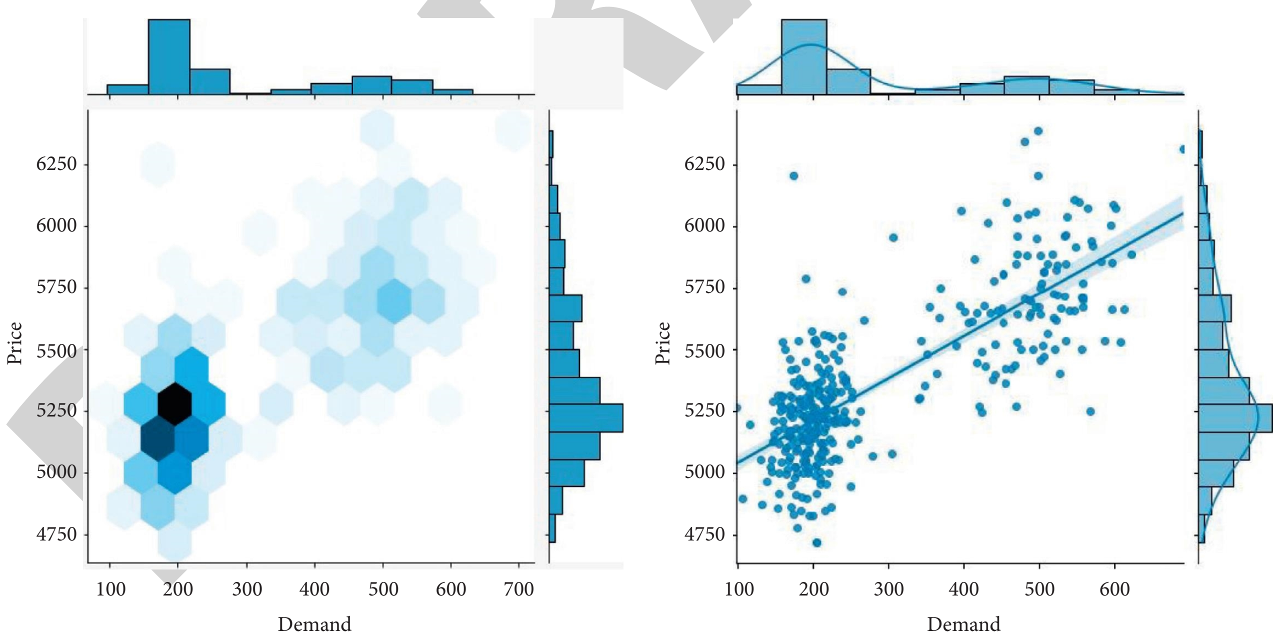


Figure 13: Price plot with demand.

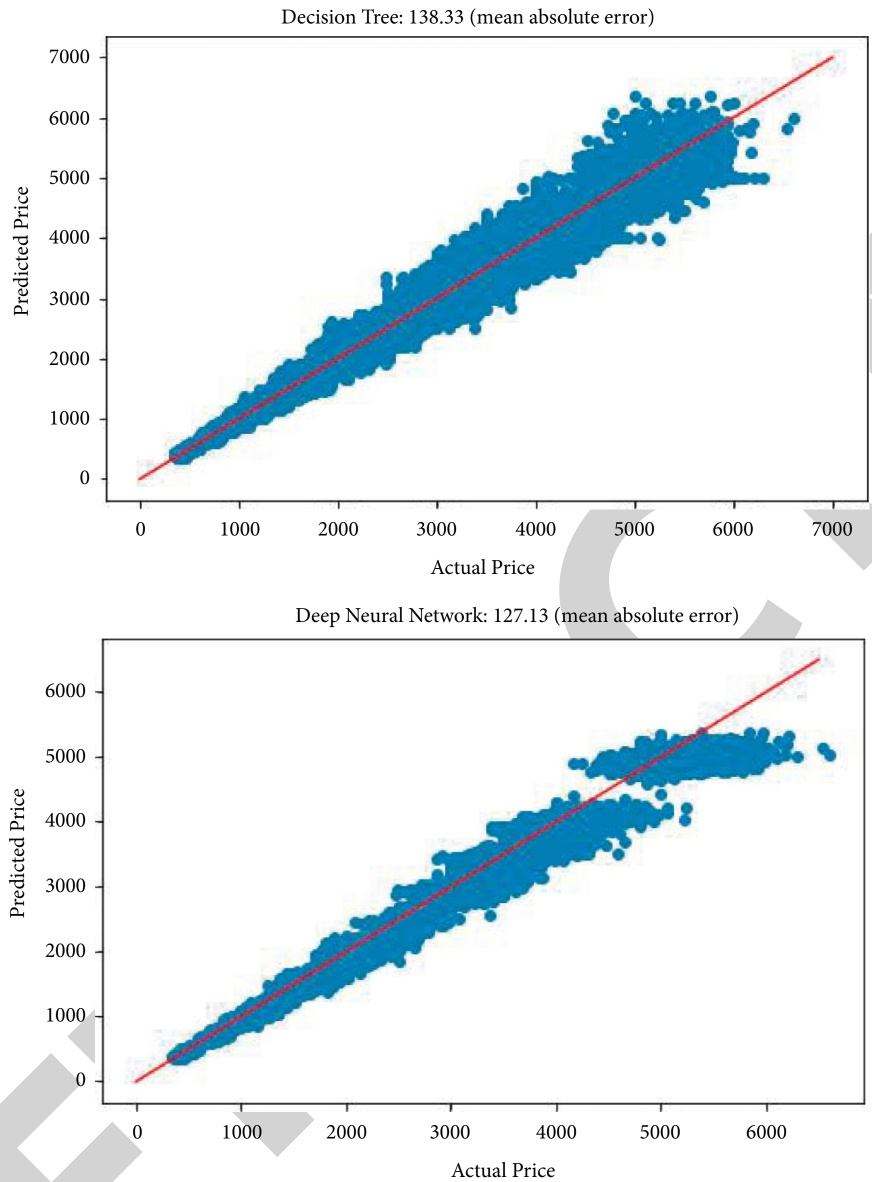


Figure 14: Comparative analysis of the machine learning algorithm.

## 5. Conclusion and Future Scope

Using a machine learning system that improves the rental and sharing of agricultural equipment's, the conclusion is formed. Based on a variety of factors, such as the level of education of farmers, the amount of land available, whether farmers have access to mobile phones, and whether or not they have to take out loans, these decisions are made. It has also been utilized to create a smartphone app that allows farmers to rent and share their agricultural equipment with one another. Surveying Punjabi farmers from several districts was the goal of this study. A total of 562 farmers were polled for this study, which resulted in the information shown. There are certain important challenges that are directly connected to farming-related difficulties that have been uncovered via the data analysis. They are unaware of the latest technologies because of their lack of education. Borrowing has become a problem for some of the countries' poorer farmers. Some farmers, on the other hand, are a landlord, which means they own more land than they need, but they still lack basic knowledge about farming.

On the second aim, the framework of the demand and supply algorithm was centered on the rental and hiring of equipment's based on seasonal swings in demand from farmers. Many sectors in the contemporary age are automating tasks that formerly required human labor. Irrigation, planting, and harvesting are all duties that farm robots can accomplish. The farm operator and farm power and equipment are essential for increasing agricultural output and productivity, but this machinery is not easily accessible to every farmer. By putting up service centers in India, custom hiring companies provide their consumers more options. For renting and sharing equipment, a machine learning approach known as a decision tree is effective.

Smart Tillage is primarily concerned with improving the quality and efficiency of agricultural production. In addition, this will assist to enhance the farmer's lifestyle by decreasing the burdensome tasks and hard work that are required. The focus of this thesis was on the use of equipment sharing and rental to create smart farming. This latest research may be able to make use of the information that was gathered via this poll on supply and demand. From the results of this poll and the feedback we received from farmers, we developed an information system called "Smart Tillage" that allows farmers to share and rent agricultural equipment. A Google API was employed in this research to track down the present position of the farmer who is renting the equipment under investigation. With this, a farmer interested in renting equipment will be informed of the precise distance, travel costs, and number of days he wants to rent the equipment before making a reservation.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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